U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-265 750

Montana AQMA Area Source Emission Inventory

PEDCo-Environmental Specialists, Inc, Cincinnati, Ohio

Prepared for

Environmental Protection Agency, Denver, Colo Air Planning and Operations Section

Dec 75

EPA-908/1-76-005

PB 265 750

DECEMBER 1975

ENVIRONMENTAL PROTECTION AGENCY
REGION VIII LIBRARY
APR 15 1977
DENVER

MONTANA AQMA AREA SOURCE EMISSION INVENTORY

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
AIR & HAZARDOUS MATERIALS DIVISION
DENVER, COLORADO 80203

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-908/1-76-005	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Montana AQMA Area Source Emission Inventory		5. REPORT DATE December 1975
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS PEDCo - Environmental Specialists, Inc. Suite 13, Atkinson Square Cincinnati, Ohio 45246		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO. 68-02-1375 Task Order No. 19
12. SPONSORING AGENCY NAME AND ADDRESS U. S. Environmental Protection Agency Region VIII 1860 Lincoln Street Denver, Colorado 80203		13. TYPE OF REPORT AND PERIOD COVERED Final
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report contains emission estimates for non point sources of air pollution in AQMA counties of the State of Montana. Estimates for particulate and sulfur oxide emissions are made for the base year (present), 1980 and 1985. Methodologies and data sources are presented.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Fuel Combustion Emissions Mobile Sources Stationary Sources	Air Quality Maintenance Analysis	

18. DISTRIBUTION STATEMENT Unlimited	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 168
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE Pc A08 mF A01

EPA Form 2220-1 (9-73)

EPA-908/1-76-005

PEDCo-ENVIRONMENTAL
SUITE 13 • ATKINSON SQUARE
CINCINNATI, OHIO 45246
513/771-4330

MONTANA AQMA AREA SOURCE EMISSION INVENTORY

Prepared by

PEDCo-ENVIRONMENTAL SPECIALISTS, INC.
Suite 13, Atkinson Square
Cincinnati, Ohio 45246

Contract No. 68-02-1375
Task Order No. 19

EPA Project Officer: David Kircher

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Region VIII
Air Planning and Operations Section
Denver, Colorado 80203

December 1975

BRANCH OFFICES

Suite 110, Crown Center
Kansas City, Mo. 64108

Suite 104-A, Professional Village
Chapel Hill, N.C. 27514

This report was furnished to the U.S. Environmental Protection Agency by PEDCo-Environmental Specialists, Inc., Cincinnati, Ohio, in fulfillment of Contract No. 68-02-1375, Task Order No. 19. The contents of this report are reproduced herein as received from the contractor. The opinions, findings, and conclusions expressed are those of the author and not necessarily those of the Environmental Protection Agency.

Material included in this report was not originally intended for publication, but to document the data sources and assumptions made in preparing the area source emission inventory. Therefore, the text may be sketchy and the report more useful as a resource document than a general procedures manual for emission inventories. It should also be pointed out that the area source emission inventory is subject to frequent updating so that data presented herein may soon become obsolete.

Publication No. EPA-908/1-76-005

CONTENTS

Page

SUMMARY 1

1. BITUMINOUS COAL 1-1
2. DISTILLATE OIL 2-1
3. RESIDUAL OIL 3-1
4. NATURAL GAS 4-1
5. OTHER FUELS 5-1
6. OPEN BURNING 6-1
7. HIGHWAY MOBILE SOURCES 7-1
8. OFF-HIGHWAY VEHICLES 8-1
9. RAILROADS 9-1
10. AIRCRAFT 10-1
11. INDUSTRIAL PROCESSES 11-1
12. UNPAVED ROADS 12-1
13. AGRICULTURE 13-1
14. CONSTRUCTION 14-1
15. AGGREGATE STORAGE PILES 15-1
16. DUST FROM PAVED ROADS 16-1

APPENDIX A POPULATION PROJECTION ASSUMPTIONS A-1

APPENDIX B VEHICLE MILES TRAVELED AND AVERAGE TRAFFIC SPEEDS, BILLINGS, MONTANA B-1

APPENDIX C PROJECTION OF PARTICULATE EMISSIONS FROM UNPAVED ROADS BY COUNTY C-1

REFERENCES 1

FIGURES

No.		Page
12.1	Distribution of ADT vs. Percent of Miles of Unpaved Roads	12-7
B.1	Billings, Montana Urban Area	B-2
B.2	Missoula, Montana Urban Area	B-7

TABLES

No.		Page
1	Area Source Particulate Emissions	3
2	Area Source Sulfur Dioxide Emissions	5
1.1	1974 Area Source Coal Emissions	1-3
2.1	1974 Area Source Distillate Fuel Oil Consumption	2-2
2.2	1974 Area Source Distillate Oil Emissions	2-5
2.3	Projections of Residential Consumption of Distillate Fuel Oil	2-7
2.4	Projections of Commercial-Institutional Consumption of Distillate Fuel Oil	2-8
2.5	Projections of Industrial Consumption of Distillate Fuel Oil	2-10
3.1	1974 Residual Oil Consumption	3-2
3.2	1974 Residual Oil Emissions	3-4
3.3	Projections of Commercial-Institutional Usage of Residual Oil	3-6
3.4	Projections of Industrial Consumption of Residual Oil	3-7
4.1	1974 Area Source Natural Gas Emissions	4-2
4.2	Projections of Natural Gas Emissions	4-4
5.1	1974 Area Source Wood Emissions	5-2
5.2	1974 Area Source LPG Consumption	5-4
5.3	1974 Area Source LPG Emissions	5-6
5.4	Projection of Other Fuel Emissions--Wood	5-7
5.5	Projection of Other Fuel Emissions--LPG	5-9
6.1	1974 Area Source Open Burning Emissions	6-2
6.2	Projection of Agricultural Burning Emissions	6-6

7.1 Annual Vehicle Miles Traveled by Vehicle Type 7-2

7.2 1974 Area Source Vehicle Emissions 7-4

7.3 VMT Projection by County 7-5

7.4 Highway Mobile Source Emission Projection 7-7

8.1 Off-Highway Gasoline Fuel Consumption 8-2

8.2 Off-Highway Diesel Fuel Consumption 8-4

8.3 1974 Off-Highway Emissions--Gasoline and Diesel 8-5

8.4 Economic Activity Growth Factors 8-8

8.5 Projection of Off-Highway Vehicle Emissions 8-9

9.1 1974 Railroad Operating Data 9-2

9.2 1974 Railroad Emissions 9-5

10.1 1974 Airport LTO Cycles 10-2

10.2 1974 LTO Cycles by Aircraft Type 10-4

10.3 1974 Aircraft Emissions 10-5

10.4 Projected 1979 and 1987 Aircraft Operations 10-7

10.5 Aircraft Activity Growth Factor 10-8

10.6 Projection of Aircraft Emissions 10-9

12.1 1974 Montana Unpaved Roads 12-2

12.2 1974 Particulate Emissions 12-5

12.3 VMT Projection by County 12-8

12.4 Unpaved Roads Particulate Matter Emission Factor Development 12-10

12.5 Average ADT on Unpaved Roads 12-11

12.6 Summary of Particulate Emissions Projections from Unpaved Roads 12-12

13.1 1974 Agriculture Emissions 13-2

13.2 Agricultural Operations 13-10
13.3 Summary of Windblown Dust and Agricultural Operations Emissions 13-11
13.4 Development of Agricultural Growth Factors 13-12
13.5 Projections of Windblown Dust Emissions 13-13
13.6 Projections of Agricultural Operations Emissions 13-15
14.1 1974 Highway Construction 14-3
14.2 1974 Area Source Construction Emissions 14-4
14.3 Projected Highway Construction 14-7
15.1 1974 Area Source Emissions from Aggregate Storage Piles 15-2
16.1 Emissions from Paved Roads 16-2
16.2 Paved Roads Particulate Emission Projection 16-4
A Montana AQMA County Population Projections A-3
B.1 Estimation of Baseline VMT, Billings B-3
B.2 Comparison of Trip Generation and Travel Characteristics, Billings B-4
B.3 Projections of VMT and Travel Speeds, Billings B-5
B.1 Estimation of Baseline VMT, Missoula B-8
B.2 Comparison of Trip Generation and Travel Characteristics, Missoula B-9
B.3 Projections of VMT and Travel Speeds, Missoula B-10
B.4 Vehicle Miles Traveled by Vehicle Type, Billings and Missoula B-11
C.1 Summary of Flathead County Unpaved Road Emission Projection C-1
C.2 Summary of Lake County Unpaved Road Emission Projections C-2

C.3	Summary of Missoula County Unpaved Road Emission Projection	C-3
C.4	Summary of Lewis & Clark County Unpaved Road Emission Projection	C-4
C.5	Summary of Deer Lodge County Unpaved Road Emission Projection	C-5
C.6	Summary of Silver Bow County Unpaved Road Emission Projection	C-6
C.7	Summary of Yellowstone County (Billings) Unpaved Road Emission Projection	C-7
C.8	Summary of Carbon County Unpaved Road Emission Projection	C-8
C.9	Summary of Stillwater County Unpaved Road Emission Projection	C-9
C.10	Summary of Sweetgrass County Unpaved Road Emission Projection	C-10
C.11	Summary of Big Horn County Unpaved Road Emission Projection	C-11
C.12	Summary of Rosebud County Unpaved Road Emission Projection	C-12
C.13	Summary of Treasure County Unpaved Road Emission Projection	C-13
C.14	Summary of Custer County Unpaved Road Emission Projection	C-14
C.15	Summary of Fallon County Unpaved Road Emission Projection	C-15
C.16	Summary of Powder River County Unpaved Road Emission Projection	C-16
C.17	Summary of Carter County Unpaved Road Emission Projection	C-17

SUMMARY

This report presents a base year 1974 air pollutant emissions inventory of area sources in the six Montana Air Quality Maintenance Areas (AQMA's) and emission projections for 1980 and 1985.

The Kalispell AQMA encompasses Flathead and Lake Counties and is designated for particulates. The Missoula AQMA contains only Missoula County and is designated for particulates and carbon monoxide (CO). The Helena AQMA contains only Lewis & Clark County and is designated for particulates and sulfur dioxide (SO_2). The Anaconda-Butte AQMA includes Deer Lodge and Silver Bow Counties and is also designated for particulates and SO_2. The Billings AQMA encompasses Yellowstone, Carbon, Stillwater, Sweetgrass, and Big Horn Counties and is designated for particulates, SO_2, and CO. The Coal Area AQMA includes Rosebud, Treasure, Custer, Fallon, Powder River, and Carter Counties and is designated for particulates and SO_2.

Carbon monoxide emissions were not calculated for the Billings and Missoula AQMA's. These data are presented in a separate report on automotive emissions in these two AQMA's.

A base year of 1974 was specified for the inventory in order that it would be consistent with the time frame of the point source emission inventory also being prepared. At the time that this inventory was done, 1974 was the most recent year for which data could be obtained for the entire year.

The base year area source emissions are projected to two different future years--1980 and 1985--as part of this report. These analysis years are specified in the EPA regulations on preparation of AQMA plans. Emissions for some of the source categories were projected to the years

1980 and 1985 on the basis of expected population growth. The procedure used to make the population projections is outlined in Appendix A.

The area source categories included in this inventory are shown in the Contents. The inventory includes all conventional source categories described in the Guide for Compiling a Comprehensive Emission Inventory, APTD-1135, plus some additional categories of fugitive dust sources. Two of the conventional categories, incinerators and vessels, were excluded since few exist in the AQMA's.

The base year annual emissions in tons, along with projected emissions, are shown in Table 1 and 2 for each inventoried source category. The survey data and methodology used to estimate emissions for each source category are documented in detail in the body of this report.

The area source categories showing the greatest particulate emissions are fugitive dust sources. Fugitive dust accounts for 91 percent of the area source particulate emissions in the Helena AQMA, 92 percent in the Missoula AQMA, 93 percent in the Kalispell and the Anaconda-Butte AQMA's, and 98 percent in the Coal Area AQMA. The largest fugitive dust source in all counties is traffic on unpaved roads.

Table 1. AREA SOURCE PARTICULATE EMISSIONS
(ton/yr)

	Source category								
Year/County	Bit coal	Dist oil	Res oil	Nat gas	Other fuels	Open burn.	Hwy	Off-hwy	Rail
1974									
Flathead	neg	90	103	11	23	9028	235	38	45
Lake	4	37	13	neg	26	884	104	23	1
Missoula	17	73	102	18	18	3711	280	46	24
Lewis & Clark	2	21	26	12	9	5201	168	46	8
Deer Lodge	neg	5	3	5	10	868	67	5	5
Silver Bow	4	19	26	16	8	978	160	27	10
Yellowstone	23	69	108	35	5	51	361	102	24
Carbon	18	5	2	1	1	406	60	19	6
Stillwater	6	3	3	neg	3	256	52	13	8
Sweetgrass	1	2	1	1	4	374	43	9	9
Big Horn	16	7	5	2	2	38	93	18	16
Rosebud	15	4	6	1	4	139	62	12	39
Treasure	5	1	neg	neg	neg	3	17	5	6
Custer	8	5	5	7	1	12	70	17	46
Fallon	7	1	2	6	neg	37	24	9	5
Powder River	6	2	1	4	2	484	22	11	neg
Carter	neg	3	neg	neg	1	128	14	10	neg
1980									
Flathead	neg	102	124	12	24	9031	277	42	45
Lake	4	42	16	neg	29	885	122	25	1
Missoula	17	84	123	18	20	3712	384	50	24
Lewis & Clark	2	24	31	12	9	5203	194	51	8
Deer Lodge	neg	6	3	5	10	868	75	5	5
Silver Bow	4	22	30	16	8	978	169	29	10
Yellowstone	23	76	122	39	5	59	531	116	24
Carbon	18	5	2	1	1	409	69	21	6
Stillwater	6	3	3	1	3	261	59	14	8
Sweetgrass	1	2	1	1	4	375	49	10	9
Big Horn	16	8	6	2	2	44	111	20	16
Rosebud	15	4	6	1	4	141	77	13	39
Treasure	5	1	neg	neg	neg	3	20	5	6
Custer	8	6	6	8	1	14	76	18	46
Fallon	7	1	2	6	neg	43	26	10	5
Powder River	6	neg	1	1	1	487	26	12	neg
Carter	neg	2	1	neg	1	131	17	11	neg
1985									
Flathead	neg	111	141	13	25	9032	278	44	45
Lake	4	45	18	neg	32	886	121	27	1
Missoula	17	93	139	21	21	3712	477	53	24
Lewis & Clark	2	27	35	14	10	5203	190	54	8
Deer Lodge	neg	5	3	5	9	868	71	5	5
Silver Bow	4	23	34	17	9	978	152	31	10
Yellowstone	23	81	133	48	5	61	663	124	24
Carbon	18	5	3	1	1	409	66	24	6
Stillwater	6	3	4	2	3	263	57	16	8
Sweetgrass	1	2	1	1	4	376	48	11	9
Big Horn	16	8	7	2	2	45	112	22	16
Rosebud	15	4	9	2	4	142	82	15	39
Treasure	5	1	neg	neg	neg	4	19	6	6
Custer	8	6	6	10	1	14	71	21	46
Fallon	7	1	2	6	neg	44	25	11	5
Powder River	6	neg	1	neg	neg	487	26	13	neg
Carter	neg	2	1	neg	1	131	17	13	neg

Table 1 (continued). AREA SOURCE PARTICULATE EMISSIONS (ton/yr)

		Source category					
Year/County	Air	Unpaved roads	Agri	Const	Aggreg	Paved roads	Total
1974							
Flathead	1	66,550	93	49	34	562	76,862
Lake	neg	46,069	128	neg	33	233	47,555
Missoula	3	45,767	24	246	25	704	51,058
Lewis & Clark	3	55,434	76	33	27	406	61,472
Deer Lodge	neg	11,574	18	neg	8	170	12,708
Silver Bow	2	14,270	7	1113	8	414	17,062
Yellowstone	8	44,900	3061	464	40	925	50,176
Carbon	neg	29,480	1215	153	30	136	31,532
Stillwater	neg	20,036	498	neg	21	123	21,022
Sweetgrass	neg	14,609	84	16	46	103	15,302
Big Horn	neg	32,761	981	64	64	221	34,288
Rosebud	neg	23,608	851	neg	58	144	24,943
Treasure	neg	3,699	1098	neg	13	43	4,890
Custer	1	17,270	1426	142	24	172	19,206
Fallon	neg	14,856	445	neg	39	50	15,481
Powder River	neg	13,130	110	129	9	48	13,958
Carter	neg	8,607	138	neg	58	31	8,990
1980							
Flathead	1	73,200	88	127	34	663	83,770
Lake	neg	51,000	122	65	33	273	52,617
Missoula	3	56,000	23	137	25	964	61,584
Lewis & Clark	3	61,300	73	neg	27	467	67,404
Deer Lodge	neg	12,000	17	neg	8	189	13,201
Silver Bow	2	14,800	7	26	8	439	16,548
Yellowstone	11	58,900	2975	465	40	1360	64,746
Carbon	neg	31,900	1156	neg	30	155	33,773
Stillwater	neg	20,800	489	neg	21	139	21,807
Sweetgrass	neg	15,900	80	neg	46	118	16,596
Big Horn	neg	37,300	984	798	64	263	39,634
Rosebud	neg	28,200	846	2396	58	180	31,980
Treasure	neg	4,200	1064	293	13	49	5,659
Custer	1	18,500	1416	294	24	187	20,605
Fallon	neg	16,000	446	neg	39	55	16,640
Powder River	neg	14,800	106	175	9	56	15,680
Carter	neg	9,900	135	neg	58	37	10,293
1985							
Flathead	2	80,900	85	78	34	783	91,571
Lake	neg	53,800	117	neg	33	319	55,403
Missoula	4	63,500	23	243	25	1321	69,673
Lewis & Clark	4	65,900	71	18	27	537	72,100
Deer Lodge	neg	12,700	16	neg	8	209	13,904
Silver Bow	2	15,200	6	neg	8	465	16,939
Yellowstone	13	66,800	1866	381	40	1999	72,261
Carbon	neg	35,000	1110	neg	30	177	36,850
Stillwater	neg	20,900	473	102	21	157	22,015
Sweetgrass	neg	18,000	77	214	46	136	18,926
Big Horn	neg	41,300	953	147	64	313	43,007
Rosebud	neg	33,000	819	neg	58	225	34,414
Treasure	neg	4,600	1024	neg	13	56	5,734
Custer	1	20,000	1369	179	24	204	21,960
Fallon	neg	17,500	432	neg	39	61	18,133
Powder River	neg	16,700	103	neg	9	65	17,410
Carter	neg	11,400	130	neg	58	43	11,796

Table 2. AREA SOURCE SULFUR DIOXIDE EMISSIONS
(ton/yr)

	Source category									
Year/County	Bit coal	Dist oil	Res oil	Nat gas	Other fuels	Hwy	Off-hwy	Rail	Air	Total
1974										
Flathead	-	428	842	1	4	91	34	102	1	1503
Lake	6	177	107	neg	5	40	16	2	neg	353
Missoula	25	345	839	1	4	108	47	54	3	1426
Lewis & Clark	2	100	214	1	2	65	48	17	4	453
Deer Lodge	-	23	25	neg	1	26	4	11	neg	90
Silver Bow	6	94	214	1	2	62	28	23	4	434
Yellowstone	34	322	880	2	2	140	96	56	13	1545
Carbon	26	18	19	neg	neg	22	13	13	neg	111
Stillwater	10	16	23	neg	neg	20	9	19	neg	97
Sweetgrass	2	11	6	neg	1	17	6	20	neg	63
Big Horn	23	31	50	neg	1	36	13	37	neg	191
Rosebud	21	17	50	neg	1	24	8	88	neg	209
Treasure	7	7	3	neg	neg	7	3	14	neg	41
Custer	11	26	39	neg	neg	27	14	106	neg	223
Fallon	10	7	10	neg	neg	9	6	11	neg	53
Powder River	10	6	8	neg	neg	9	7	neg	neg	40
Carter	-	11	6	neg	neg	6	7	neg	neg	30
1980										
Flathead	-	484	1015	1	4	107	38	102	2	1753
Lake	6	196	128	neg	5	47	18	2	neg	402
Missoula	25	398	1007	1	4	149	52	54	4	1694
Lewis & Clark	2	113	253	1	2	75	53	17	5	521
Deer Lodge	-	22	26	neg	1	29	4	11	neg	93
Silver Bow	6	102	249	1	2	66	31	23	4	484
Yellowstone	34	358	995	2	2	206	109	56	18	1780
Carbon	26	21	21	neg	neg	25	15	13	neg	121
Stillwater	10	17	28	neg	neg	23	10	19	neg	107
Sweetgrass	2	11	7	neg	1	19	7	20	neg	67
Big Horn	23	34	47	neg	1	43	14	37	neg	199
Rosebud	21	20	62	neg	1	30	9	88	neg	231
Treasure	7	8	5	neg	neg	8	4	14	neg	46
Custer	11	29	45	1	neg	30	15	106	neg	237
Fallon	10	8	10	neg	neg	10	7	11	neg	56
Powder River	10	5	7	neg	neg	10	8	neg	neg	40
Carter	-	10	6	neg	neg	7	8	neg	neg	31
1985										
Flathead	-	528	1151	1	4	127	40	102	3	1956
Lake	6	215	145	neg	5	55	19	2	neg	447
Missoula	25	442	1141	1	5	204	55	54	5	1932
Lewis & Clark	2	122	281	1	2	86	57	17	5	573
Deer Lodge	-	23	26	neg	1	32	4	11	neg	97
Silver Bow	6	110	278	1	2	69	33	23	5	527
Yellowstone	34	496	1089	3	2	302	116	56	22	2120
Carbon	26	21	24	neg	neg	29	16	13	neg	129
Stillwater	10	20	31	neg	neg	26	11	19	neg	117
Sweetgrass	2	12	8	neg	1	22	7	20	neg	72
Big Horn	23	36	52	neg	1	51	15	37	neg	215
Rosebud	21	23	71	neg	2	37	10	88	neg	252
Treasure	7	9	6	neg	neg	9	4	14	neg	49
Custer	11	17	50	1	neg	32	17	106	neg	234
Fallon	10	8	11	neg	neg	11	8	11	neg	59
Powder River	10	4	8	neg	neg	12	9	neg	neg	43
Carter	-	10	7	neg	neg	8	8	neg	neg	33

1. BITUMINOUS COAL

DATA INVENTORY AND METHODOLOGY

The area source consumption of coal was determined by using the degree-day heating method for calculating residential coal consumption. Commercial-institutional and industrial area source coal consumption were assumed to be negligible.

Residential

Of the coal distributors contacted, only three sold coal directly to the residential customer. These sales were usually picked up by the buyer. No record of where the coal was to be burned was kept. Only the total sales in tons were recorded for each company. These are listed below:

1974 Coal sales, approximate tonnage	
Hamilton, Montana[1]	200 tons
Butte, Montana[2]	760 tons
Roundup, Montana[3]	10,000 tons

Due to the incompleteness of the coal distributors' records and the large area served, no conclusions could be drawn from this data. Therefore, only the estimates of coal consumption generated by the degree-day method were used to calculate emissions.

Residential coal consumption was calculated using the degree-day heating method.[4] The general equation is:

$$RFC = (DU) \times (DD) \times (HRF) \times (R) \qquad \text{(eq.1)}$$

where RFC = residential fuel consumption, tons
DU = dwelling units
DD = degree-days
HRF = heating requirement factor, tons of coal per dwelling unit per degree-day
R = correction factor for number of rooms per dwelling unit, average number of rooms/5.0 rooms

In spite of population increases from 1970 to 1974 it was assumed that the number of 1970 dwelling units using coal[5] was representative of 1974. According to information provided by the coal distributors, the decrease in coal sales evident in recent years had leveled off and coal sales were now increasing. Therefore, it was felt that a reasonable estimate for residential coal consumption could be based on the number of dwelling units using coal in 1970. The number of degree-days was determined for each county from the nearest National Weather Service (NWS) reporting station.[6] The heating requirement factor for tons of coal burned is 0.0012 tons/dwelling unit/degree-day.[4] The average number of rooms per dwelling unit was determined from reference 5. The data needed to calculate coal consumption and the calculated coal consumption are listed in Table 1.1.

Commercial-Institutional

Since the 1974 calculated residential coal consumption for the AQMA counties was greater than the Bureau of Mines retail dealers bituminous coal figure for the state,[7] it was assumed that the commercial-institutional coal consumption area source emissions were negligible.[4]

Table 1.1. 1974 AREA SOURCE COAL EMISSIONS

County	1970 DU using coal[a]	1974 Heating degree-days[b]	Average rooms/ dwelling unit[a]	Residential coal usage, ton/yr	1974 Emissions, ton/yr	
					Partic	SO_2
Flathead	-	7686	4.8	-	-	-
Lake	45	7686	4.6	382	3.8	5.6
Missoula	215	7305	4.6	1734	17.3	25.4
Lewis & Clark	19	7594	4.6	159	1.6	2.3
Deer Lodge	-	7594	4.3	-	-	-
Silver Bow	53	7594	4.5	435	4.4	6.4
Yellowstone	303	6763	4.7	2311	23.1	33.8
Carbon	224	6763	4.8	1745	17.5	25.5
Stillwater	83	6763	4.8	647	6.5	9.5
Sweetgrass	18	6763	4.8	140	1.4	2.0
Big Horn	209	6763	4.6	1560	15.6	22.8
Rosebud	205	7084	4.2	1464	14.6	21.4
Treasure	61	7084	4.9	508	5.1	7.4
Custer	95	7084	4.7	759	7.6	11.1
Fallon	82	7084	4.9	683	6.8	10.0
Powder River	83	7084	4.6	649	6.5	9.5
Carter	-	7084	4.9	-	-	-

[a] Reference 5

[b] Reference 6

Industrial

It was assumed that all industrial coal users burned large enough quantities of coal to be included as point sources. Therefore, industrial coal combustion area source emissions were assumed to be negligible.

BASE YEAR EMISSIONS

Since all of the coal consumption is residential, emission factors for hand-fired units were used:[8]

Emission factors, lb/ton	
Particulates	20.00
SO_2	29.26 (assuming 0.77% sulfur)[9]

Applying these emission factors to the calculated residential coal consumption yields the annual emissions listed in Table 1.1.

PROJECTIONS

In projecting the consumption of bituminous coal, a number of assumptions were made; these assumptions are based on historical trends as well as expectations for the near future:

- Use of coal for the purpose of area source emissions will continue to be limited to residential uses. Just as in the base year emissions estimates, it is assumed that commercial-institutional and industrial contributions will continue to be negligible area sources.

- New residences to be built between 1974 and 1985 will not use coal as the primary heating fuel; instead, these residences will most likely be heated with natural gas, fuel oil, or electricity.

- The number of existing residences using bituminous coal will decrease through attrition; since many of the homes capable of utilizing coal for a heating fuel are the older homes, these residences are anticipated to steadily decline in numbers.

- Some residences capable of using several fuel sources will switch to coal for heating purposes as the costs of other fuel sources (e.g., natural gas, fuel oil, and electricity) steadily increase.

Although it is expected the number of older homes with coal stokers will gradually decrease through abandonment and subsequent demolition, or renovation, relative cost competitiveness of coal to other heating fuels is anticipated to encourage some residences to switch from these sources to coal. Overall, it has been assumed that these two trends will counteract each other, so that net residential bituminous coal consumption will remain unchanged from 1974 through 1980 and 1985. Since the growth factor is assumed to be 1.0 and the emission factor will remain the same, the projected emissions from this area source will remain constant over the time period of interest.

2. DISTILLATE OIL

DATA INVENTORY AND METHODOLOGY

The area source consumption of distillate oil was determined by using the degree-day heating method for residential and by apportioning the state distillate oil consumption totals for commercial-institutional and industrial.

Residential

Residential distillate oil consumption was calculated using the degree-day heating method previously discussed in Section one, page 1-2 (eq.1). The heating requirement factor for gallons of oil burned per dwelling unit per degree-day is 0.18.[4] The number of dwelling units using distillate oil and the 1974 residential distillate oil consumption are recorded in Table 2.1. The trend for house heating from 1970 to 1974 has been toward gas and electric heat; consequently, there has been no significant increase in distillate oil usage during these years. Therefore, it was assumed that the number of 1970 dwelling units using distillate oil were representative of 1974.

Commercial-Institutional

Commercial-institutional area source distillate oil consumption was calculated by apportioning the state distillate oil commercial consumption by 1974 population. State commercial distillate oil consumption for area sources was determined from 1973 published data,[10] where 1973 data were assumed to be representative of 1974.

Table 2.1. 1974 AREA SOURCE DISTILLATE FUEL OIL CONSUMPTION

County	1970 DU using fuel oil[a]	Residential consumption, 10^3 gal/yr	1974 Population[b]	1974 Commercial-institutional 10^3 gal/yr	1973 Mfg. employees[c]	1974 Point & area source industrial consumption, 10^3 gal/yr
Flathead	3733	4958	42,600	1375	3281	5709
Lake	3007	3827	16,700	539	362	630
Missoula	1401	1695	63,700	2057	3428	5965
Lewis & Clark	347	436	36,000	1162	711	1237
Deer Lodge	105	123	15,100	488	30[d]	52
Silver Bow	111	137	43,200	1395	671	1168
Yellowstone	421	482	94,300	3045	3421	5953
Carbon	175	205	7,900	255	38	66
Stillwater	144	168	5,200	168	69	120
Sweetgrass	149	174	3,100	100	10[d]	17
Big Horn	309	346	10,500	339	113	197
Rosebud	217	232	7,700	249	170	296
Treasure	107	134	1,200	39	10[d]	17
Custer	152	182	12,300	397	100	174
Fallon	42	52	3,900	126	21	37
Powder River	79	93	2,200	71	20[d]	35
Carter	220	218	1,900	61	15[d]	26
State total	29850	37168	735,000	23732	22229	38682

[a] Reference 5

[b] Reference 11

[c] Reference 12

[d] Estimated from reference 12

State distillate type heating oil = 56,154 · 10^3 gal

State distillate used by military = 1,218 · 10^3 gal

State kerosene used for heating = 3,528 · 10^3 gal

1974 State residential and commercial distillate oil consumption 60,900 · 10^3 gal

Less 1974 state residential distillate oil consumption - 37,168 · 10^3 gal

1974 State commercial-institutional distillate oil consumption 23,732 · 10^3 gal

The apportioned commercial-institutional distillate oil consumption by county is listed in Table 2.1.

Industrial

Industrial distillate oil consumption was calculated by apportioning state industrial distillate oil consumption by the number of manufacturing employees in each county. State industrial distillate oil consumption for point and area sources was determined from the following 1973 published data,[10] where 1973 data were assumed to be representative of 1974.

State industrial use = 37,380 · 10^3 gal

State oil company use = 1,302 · 10^3 gal

1974 State point and area source industrial distillate oil consumption 38,682 · 10^3 gal

The apportioned industrial distillate oil consumption by county is listed in Table 2.1. It was assumed that the

1973 ratio of county to state manufacturing employees is representative of 1974.

The 1974 point source distillate oil consumption was determined from a National Emission Data System (NEDS) computer listing for the State of Montana.[13] These totals for each county were subtracted from the calculated distillate oil consumption totals for that county to determine the 1974 area source distillate oil consumption listed in Table 2.2.

BASE YEAR EMISSIONS

The emission factors for distillate fuel oil combustion are:[8]

Emission factors, lb/10^3 gal	
Particulates	15
SO_2	71 (assuming 0.5% sulfur)[14]

Applying these factors to the county area source distillate oil consumption yields the emissions listed in Table 2.2.

PROJECTIONS

Future use of distillate oil is projected for each of the major category of users--residential, commerical-institutional, and industrial. The projections for residential and commercial-institutional uses were assumed to be proportional to population, whereas industrial growth was assumed to be related to manufacturing economic activity.

Table 2.2. 1974 AREA SOURCE DISTILLATE OIL EMISSIONS

County	1974 Point source consumption, 10^3 gal/yr[a]	1974 Area source industrial consumption, 10^3 gal/yr	1974 Area source distillate oil consumption, 10^3 gal/yr	1974 Emissions, ton/yr Partic	1974 Emissions, ton/yr SO_2
Flathead		5709	12042	90.3	427.5
Lake	25	605	4971	37.3	176.5
Missoula		5965	7180	53.9	254.9
Lewis & Clark	2	1235	2833	21.2	100.6
Deer Lodge		52	663	5.0	23.5
Silver Bow	70	1098	2630	19.7	93.4
Yellowstone	401	5552	9079	68.1	322.3
Carbon		66	526	3.9	18.7
Stillwater		120	456	3.4	16.2
Sweetgrass		17	291	2.2	10.3
Big Horn		197	882	6.6	31.3
Rosebud	768	neg	481	3.6	17.1
Treasure		17	190	1.4	6.7
Custer		174	753	5.6	26.7
Fallon		37	215	1.6	7.6
Powder River		35	199	1.5	7.1
Carter		26	305	2.3	10.8

[a] Reference 13

Residential

It was assumed that area source residential consumption of distillate oil would continue to be utilized for home heating purposes in somewhat the same manner as it has been in the past. Thus, future use of distillate oil was assumed to be proportional to the growth of the number of dwelling units currently using distillate oil, and the growth in the number of DU's was assumed to be proportional to county-wide population growth. These projected county population growth rates were used to project residential usage of distillate oil and their concomitant emissions. Results for this analysis are presented in Table 2.3 (the emission factors are assumed to be unchanged from the base year).

Commercial-Institutional

Use of distillate oil in the commercial-institutional sector was also assumed to be directly related to population changes. Therefore, projections were based on the county-wide changes projected for population. These results are shown in Table 2.4. Again, the same emission factors used in the baseline emissions estimates were used.

Industrial

Growth factors for industrial consumption of distillate oil were calculated from OBERS BEA economic area projections.[15] The AQMA counties are distributed among three BEA economic areas:

- Area 153 - Butte, Montana
- Area 094 - Great Falls, Montana
- Area 095 - Billings, Montana

TABLE 2. 3. PROJECTIONS OF RESIDENTIAL CONSUMPTION OF DISTILLATE FUEL OIL

	1974				1980				1985		
County	Consumption 10^3gal/yr	Emission tons/yr Part.	Emission tons/yr SO_2	Growth Factor	Consumption 10^3gal/yr	Emission tons/yr Part.	Emission tons/yr SO_2	Growth Factor	Consumption 10^3gal/yr	Emission tons/yr Part.	Emission tons/yr SO_2
Flathead	4958	37.2	176	1.056	5255	39.4	186	1.101	5454	40.9	194
Lake	3827	28.7	136	1.102	4210	31.6	149	1.186	4554	34.2	162
Missoula	1695	12.7	60	1.064	1797	13.5	64	1.119	1898	14.2	67
Lewis & Clark	436	3.3	15	1.056	462	3.5	16	1.103	480	3.6	17
Deer Lodge	123	0.9	4	0.957	117	0.9	4	0.901	111	0.8	4
Silver Bow	137	1.0	5	1.021	140	1.1	5	1.040	142	1.1	5
Yellowstone	482	3.6	17	1.055	511	3.8	18	1.101	530	4.0	19
Carbon	205	1.5	7	1.076	221	1.7	8	1.139	234	1.8	8
Stillwater	168	1.3	6	1.077	181	1.4	6	1.154	193	1.4	7
Sweetgrass	174	1.3	6	1.032	179	1.3	6	1.065	186	1.4	7
Big Horn	346	2.6	12	1.029	356	2.7	13	1.057	367	2.8	13
Rosebud	232	1.7	8	1.169	271	2.0	10	1.299	302	2.3	11
Treasure	134	1.0	5	1.083	145	1.1	5	1.167	157	1.2	6
Custer	182	1.4	6	1.008	184	1.4	7	1.016	186	1.4	7
Fallon	59	0.4	2	0.949	49	0.4	2	0.897	47	0.4	2
Powder River	93	0.7	3	0.545	50	0.4	2	0.182	17	0.1	1
Carter	218	1.6	8	0.947	207	1.6	7	0.895	194	1.5	7

TABLE 2.4. PROJECTIONS OF COMMERCIAL-INSTITUTIONAL CONSUMPTION OF DISTILLATE FUEL OIL

County	1974 Consumption 10^3 gal/yr	1974 Emission tons/yr Part.	1974 Emission tons/yr SO_2	Growth Factor	1980 Consumption 10^3 gal/yr	1980 Emission tons/yr Part.	1980 Emission tons/yr SO_2	Growth Factor	1985 Consumption 10^3 gal/yr	1985 Emission tons/yr Part.	1985 Emission tons/yr SO_2
Flathead	1375	10.3	48.8	1.056	1458	10.9	51.8	1.101	1513	11.3	53.7
Lake	539	4.0	19.1	1.102	593	4.4	21.1	1.186	641	4.8	22.8
Missoula	2057	15.4	73.0	1.064	2180	16.4	77.4	1.119	2304	17.3	81.8
Lewis & Clark	1162	8.7	41.3	1.056	1232	9.2	43.7	1.103	1278	9.6	45.4
Deer Lodge	488	3.7	17.3	0.951	464	3.5	16.5	0.901	439	3.3	15.6
Silver Bow	1395	10.5	49.5	1.021	1423	10.7	50.5	1.040	1448	10.9	51.4
Yellowstone	3045	22.8	108.1	1.055	3228	24.2	114.6	1.101	3350	25.1	118.9
Carbon	255	1.9	9.1	1.076	275	2.1	9.8	1.139	291	2.2	10.3
Stillwater	168	1.3	6.0	1.077	181	1.4	6.4	1.154	193	1.4	6.9
Sweetgrass	100	0.8	3.6	1.032	103	0.8	3.7	1.065	107	0.8	3.8
Big Horn	339	2.5	12.0	1.029	349	2.6	12.4	1.057	359	2.7	12.7
Rosebud	249	1.9	8.8	1.169	291	2.2	10.3	1.299	324	2.4	11.5
Treasure	39	0.3	1.4	1.083	42	0.3	1.5	1.167	46	0.3	1.6
Custer	397	3.0	14.1	1.088	401	3.0	14.2	1.016	405	3.0	1.4
Fallon	126	0.9	4.5	0.949	120	0.9	4.3	0.897	114	0.9	4.0
Powder River	71	0.5	2.5	0.545	38	0.3	1.3	0.182	13	0.1	0.5
Carter	61	0.5	2.2	0.947	58	0.4	2.1	0.895	54	0.4	1.9

Five of the AQMA counties are in Area 153, one is is in Area 094, and the remaining counties are in Area 095 with the exception of Yellowstone which, because it is a Standard Metropolitan Statistical Area (SMSA), is a separate BEA Economic Area (321, Billings SMSA). As no projections were readily available for Area 321 from Volume II of the OBERS projections, a different set of projections (based on Series C instead of Series E) were used for Area 321.[16] Examination of the population estimates provided indicates no substantial difference between these two sources for the years in question.

The indices used to determine the growth factors for industrial consumption of distillate oil were "manufacturing earnings." Since no data were available for 1974, the base year factor was calculated from the 1971 historical figures and the 1980 projection figures by linear extrapolation for each BEA economic area. Growth factors were then calculated for each BEA economic area and assigned to the counties within that area. These growth factors were, in turn, then applied to the base year emissions. Table 2.5 presents the results of these computations.

Table 2.5. PROJECTIONS OF INDUSTRIAL CONSUMPTION OF DISTILLATE FUEL OIL

County	BEA econ area	1974			1980				1985			
		Consumption, 10^3 gal/yr	Emissions, ton/yr Partic	Emissions, ton/yr SO_2	Growth factor	Consumption, 10^3 gal/yr	Emissions, ton/yr Partic	Emissions, ton/yr SO_2	Growth factor	Consumption, 10^3 gal/yr	Emissions, ton/yr Partic	Emissions, ton/yr SO_2
Flathead	153	5709	42.8	202.7	1.214	6931	52.0	246.1	1.384	7901	59.3	280.5
Lake	153	605	4.5	21.5	1.214	734	5.5	26.1	1.384	837	6.3	29.7
Missoula	153	5965	44.7	211.8	1.214	7242	54.3	257.1	1.384	8256	61.9	293.1
Lewis & Clark	94	1235	9.3	43.8	1.207	1491	11.2	52.9	1.361	1681	12.6	59.7
Deer Lodge	153	52	0.4	1.8	1.214	63	0.5	2.2	1.384	72	0.5	2.6
Silver Bow	153	1098	8.2	39.0	1.214	1333	10.0	47.3	1.384	1520	11.4	54.0
Yellowstone	321	5552	41.6	197.1	1.143	6346	47.6	225.3	1.259	6990	52.4	248.1
Carbon	95	66	0.5	2.3	1.248	82	0.6	2.9	1.441	95	0.7	3.4
Stillwater	95	120	0.9	4.3	1.248	150	1.1	5.3	1.441	173	1.3	6.1
Sweetgrass	95	17	0.1	0.6	1.248	21	0.2	0.7	1.441	24	0.2	0.9
Big Horn	95	197	1.5	7.0	1.248	246	1.8	8.7	1.441	284	2.1	10.1
Rosebud	95	neg	-	-	1.248	neg	-	-	1.441	neg	-	-
Treasure	95	17	0.1	0.6	1.248	21	0.2	0.7	1.441	24	0.2	0.9
Custer	95	174	1.3	6.2	1.248	217	1.6	7.7	1.441	251	1.9	8.9
Fallon	95	37	0.3	1.3	1.248	46	0.3	1.6	1.441	53	0.4	1.9
Powder River	95	35	0.3	1.2	1.248	44	0.3	1.6	1.441	50	0.4	1.8
Carter	95	26	0.2	0.9	1.248	32	0.2	1.1	1.441	37	0.3	1.3

3. RESIDUAL OIL

DATA INVENTORY AND METHODOLOGY

Area source residual oil consumption was determined by apportioning state residual oil totals for commercial-institutional and industrial usage. It was assumed that there is no residential usage of residual oil in Montana, so only commercial-institutional and industrial residual consumption was calculated.

Commercial-Institutional

Commercial-institutional area source residual oil consumption was calculated by apportioning state commercial-institutional residual oil by county/state population. The state area source consumption for this category was determined from 1973 published data.[10] The 1973 data were assumed to be representative of 1974 data. Point sources for commercial-institutional usage were neglected.

State residual type heating oil = 8,736,000 gal
State residual used by military = 672,000 gal
1974 State commercial-institutional residual oil consumption 9,408,000 gal

The 1974 Montana population is 735,000.[11] Listed in Table 3.1 is the apportioned commercial-institutional residual oil consumption by county.

Table 3.1. 1974 RESIDUAL OIL CONSUMPTION

County	1974 County population[a]	1974 Commercial-instituional residual oil consumption, 10^3 gal/yr	Manu-acturing employees[b]	1974 Point & area source industrial consumption, 10^3 gal/yr	1974 Point source industrial consumption, 10^3 gal/yr	1974 Area source industrial consumption, 10^3 gal/yr
Flathead	42600	545	3281	8400		8400
Lake	16700	214	362	927		927
Missoula	63700	815	3428	8776	682	8094
Lewis & Clark	36000	461	711	1820		1820
Deer Lodge	15100	193	30[c]	77		77
Silver Bow	43200	553	671	1718		1718
Yellowstone	94300	1207	3421	8758	630	8128
Carbon	7900	101	38	97		97
Stillwater	5200	67	69	177		177
Sweetgrass	3100	40	10[c]	26		26
Big Horn	10500	134	113	289		289
Rosebud	7700	99	170	435		435
Treasure	1200	15	10[c]	26		26
Custer	12300	157	100	256		256
Fallon	3900	50	21	54		54
Powder River	2200	28	20[c]	51		51
Carter	1900	24	15[c]	38		38

[a] Reference 11

[b] Reference 12

[c] Estimated from reference 12

Industrial

Industrial residual oil consumption was calculated by apportioning state industrial residual oil consumption by county/state manufacturing employees. State industrial residual oil consumption for point and area sources was determined from the following 1973 published data.[10] The 1973 data were assumed to be representative of 1974 data.

State industrial usage	= 10,206,000 gal
State oil company usage	= 46,704,000 gal
1974 State point and area source consumption	56,910,000 gal

The apportioned industrial residual oil consumption by county is reported in Table 3.1. The total number of manufacturing employees in the state is 22,229.[12] It was assumed that the 1973 ratio of county to state manufacturing employees is representative of 1974.

BASE YEAR EMISSIONS

The emission factors for residual oil combustion are as follows:[8]

Emission factors, $lb/10^3$ gal	
Particulates	23.0
SO_2	188.4 (assuming 1.2% sulphur)[14]

Applying these emission factors to the total county area source consumption yields the emissions listed in Table 3.2.

Table 3.2. 1974 RESIDUAL OIL EMISSIONS

County	1974 Area source residual oil consumption, 10^3 gal/yr	1974 Emissions, ton/yr	
		Partic	SO_2
Flathead	8945	102.9	842.6
Lake	1141	13.1	107.5
Missoula	8909	102.5	839.2
Lewis & Clark	2281	26.2	214.9
Deer Lodge	270	3.1	25.4
Silver Bow	2271	26.1	213.9
Yellowstone	9335	107.4	879.4
Carbon	198	2.3	18.7
Stillwater	244	2.8	23.0
Sweetgrass	66	0.8	6.2
Big Horn	423	4.9	39.8
Rosebud	534	6.1	50.3
Treasure	41	0.5	3.9
Custer	413	4.7	38.9
Fallon	104	1.2	9.8
Powder River	79	0.9	7.4
Carter	62	0.7	5.8

PROJECTIONS

Historical trends were used to project emissions from residual oil. In particular, as in the base year estimates, it was assumed there would be no residential usage and primary consumption limited to commercial-institutional and industrial categories. Furthermore, in estimating emissions, it was assumed that emission factors for particulates and SO_2 remained constant from the base year--specifically 23 lb particulate and 188.4 lb SO_2 per 1000 gal of residual oil (this factor assumes 1.2 percent sulfur content).

Commercial-Institutional

It was assumed area source commercial-institutional consumption of residual oil would continue in proportion to population. Therefore, county population growth factors were used to project residual oil consumption and the resultant emissions. These results are given in Table 3.3.

Industrial

Growth factors for industrial consumption of residual oil were calculated in the same manner as industrial distillate oil, e.g., proportional to manufacturing economic activity. The projected manufacturing earning for each county was determined from its location in the various OBERS-BEA economic areas.[15] These growth factors to the base year oil consumption figures and emission estimates yield the emissions presented in Table 3.4.

TABLE 3.3. PROJECTIONS OF COMMERCIAL-INSTITUTIONAL USAGE OF RESIDUAL OIL

	1974				1980				1985		
County	Consumption 10^3gal/yr	Emission tons/yr Part.	SO_2	Growth Factor	Consumption 10^3gal/yr	Emission tons/yr Part.	SO_2	Growth Factor	Consumption 10^3gal/yr	Emission tons/yr Part.	SO_2
Flathead	545.28	6.3	51.4	1.056	578.0	6.6	54.4	1.101	599.8	6.9	56.5
Lake	213.76	2.5	20.1	1.102	235.1	2.7	22.1	1.186	254.4	2.9	24.0
Missoula	815.36	9.4	76.8	1.064	864.3	9.9	81.4	1.119	913.2	10.5	86.0
Lewis & Clark	460.80	5.3	43.4	1.056	488.4	5.6	46.0	1.103	506.9	5.8	47.8
Deer Lodge	193.28	2.2	18.2	0.957	183.6	2.1	17.3	0.901	174.0	2.0	16.4
Silver Bow	552.96	6.4	52.1	1.021	564.0	6.5	53.1	1.040	575.0	6.6	54.2
Yellowstone	1207.04	13.9	113.7	1.055	1279.5	14.7	120.5	1.101	1327.8	15.3	125.1
Carbon	101.12	1.2	9.5	1.076	109.2	1.3	10.3	1.139	115.3	1.3	10.9
Stillwater	66.56	0.8	6.3	1.077	71.9	0.8	6.8	1.154	76.5	0.9	7.2
Sweetgrass	39.68	0.5	3.7	1.032	40.9	0.5	3.9	1.065	42.5	0.5	4.0
Big Horn	134.40	1.5	12.7	1.029	138.4	1.6	13.0	1.057	142.5	1.6	13.4
Rosebud	98.56	1.1	9.3	1.169	115.3	1.3	10.9	1.299	128.1	1.5	12.1
Treasure	15.36	0.2	1.4	1.083	16.6	0.2	1.6	1.167	18.0	0.2	1.7
Custer	157.44	1.8	14.8	1.088	159.0	1.8	15.0	1.016	160.6	1.8	15.1
Fallon	49.90	0.6	4.7	0.949	47.4	0.5	4.5	0.897	44.9	0.5	4.2
Powder River	28.16	0.3	2.7	0.545	15.2	0.2	1.4	0.182	5.0	0.1	0.5
Carter	24.32	0.3	2.3	0.947	23.1	0.3	2.2	0.895	21.6	0.2	2.0

Table 3.4. PROJECTIONS OF INDUSTRIAL CONSUMPTION OF RESIDUAL OIL

		1974				1980				1985		
County	BEA econ area	Consumption, 10^3 gal/yr	Emissions, ton/yr Partic	Emissions, ton/yr SO_2	Growth factor	Consumption, 10^3 gal/yr	Emissions, ton/yr Partic	Emissions, ton/yr SO_2	Growth factor	Consumption, 10^3 gal/yr	Emissions, ton/yr Partic	Emissions, ton/yr SO_2
Flathead	153	8400	96.6	791.3	1.214	10198	117.3	960.7	1.384	11626	133.7	1095.2
Lake	153	927	10.7	87.3	1.214	1125	12.9	106.0	1.384	1283	14.8	120.9
Missoula	153	8094	93.1	762.5	1.214	9826	113.0	925.6	1.384	11202	128.8	1055.2
Lewis & Clark	94	1820	20.9	171.4	1.207	2197	25.3	207.0	1.361	2477	28.5	233.3
Deer Lodge	153	77	0.9	7.3	1.214	93	1.1	8.8	1.384	107	1.2	10.1
Silver Bow	153	1718	19.8	161.8	1.214	2086	24.0	196.5	1.384	2378	27.3	224.0
Yellowstone	321	8123	93.5	765.7	1.143	9290	106.8	875.1	1.259	10233	117.7	963.9
Carbon	95	97	1.1	9.1	1.248	121	1.4	11.4	1.441	140	1.6	13.2
Stillwater	95	177	2.0	16.7	1.248	221	2.5	20.8	1.441	255	2.9	24.0
Sweetgrass	95	26	0.3	2.4	1.248	32	0.4	3.0	1.441	37	0.4	3.5
Big Horn	95	289	3.3	27.2	1.248	361	4.2	34.0	1.441	416	4.8	39.2
Rosebud	95	435	5.0	41.0	1.248	543	5.2	51.2	1.441	627	7.2	59.1
Treasure	95	26	0.3	2.4	1.248	32	0.4	3.0	1.441	37	0.4	3.5
Custer	95	256	2.9	24.1	1.248	319	3.7	30.0	1.441	369	4.2	34.8
Fallon	95	54	0.6	5.1	1.248	67	0.8	6.3	1.441	78	0.9	7.3
Powder River	95	51	0.6	4.8	1.248	64	0.7	6.0	1.441	73	0.8	6.9
Carter	95	38	0.4	3.6	1.248	47	0.5	4.4	1.441	55	0.6	5.2

4. NATURAL GAS

DATA INVENTORY AND METHODOLOGY

The consumption of natural gas in the Montana AQMA counties was determined by contact with the natural gas distributors. The distributors provided data on natural gas deliveries to a few industrial sources and total deliveries to the AQMA counties.[17,18] The total 1974 point source natural gas consumption for each county was determined from data provided by the natural gas distributors and from a NEDS computer listing for the State of Montana.[13] Area source natural gas consumption was calculated by subtracting 1974 point source natural gas consumption totals from the total natural gas deliveries for each county. These totals are listed in Table 4.1.

BASE YEAR EMISSIONS

The emission factors for natural gas combustion are:[8]

Emission factors, lb/10^6 cu ft	
Particulate -	10.0
SO_2 -	0.6

Applying these emission factors to the county area source natural gas consumption yields the emissions recorded in Table 4.1.

Table 4.1. 1974 AREA SOURCE NATURAL GAS EMISSIONS

County	1974 Natural gas deliveries, 10^6 cu ft	1974 Point source natural gas consumption, 10^6 cu ft	1974 Area source natural gas consumption, 10^6 cu ft	1974 Emissions, ton/yr Partic	1974 Emissions, ton/yr SO_2
Flathead	2741	565	2176	10.9	0.7
Lake	0	0	0	0	0
Missoula	8958	5462	3496	17.5	1.0
Lewis & Clark	2921	584	2337	11.7	0.7
Deer Lodge	10483	9397	1086	5.4	0.3
Silver Bow	4683	1509	3174	15.9	1.0
Yellowstone	11558	4603	6955	34.8	2.1
Carbon	210	0	210	1.0	0.1
Stillwater	59	0	59	0.3	0
Sweetgrass	141	0	141	0.7	0
Big Horn	365	0	365	1.8	0.1
Rosebud	195	0	195	1.0	0.1
Treasure	0	0	0	0	0
Custer	1457	0	1457	7.3	0.4
Fallon	1153	0	1153	5.8	0.3
Powder River	814	0	814	4.1	0.2
Carter	0	0	0	0	0

PROJECTIONS

Two major utilities provided much of the information used in developing the projections for natural gas usage.[17,18] The Montana Power Company provided base year consumption estimates for 1974 for the counties of Flathead, Lake, Missoula, Lewis & Clark, Deer Lodge, Silver Bow, and Sweetgrass. In addition to base year estimates for 1974, the Montana-Dakota Utilities Company provided projections for 1980 and 1985 for the counties of Yellowstone, Carbon, Stillwater, Big Horn, Rosebud, Custer, Fallon, and Powder River. The latter data were also disaggregated into residential, commercial, industrial, and company use categories. With the exception of Yellowstone County, all natural gas usage estimates were assumed to be responsible for area source emissions. In Yellowstone County, a decrease in industrial usage from 5543 MMCF in 1974 to 3821 MMCF for 1980 and 1985 was projected. The difference of 1722 MMCF (i.e., 5543-3821 MMCF) was assumed to be attributable to an industrial point source (assumed to be switching to other fuels) and subtracted from the industrial category for 1974. All other data, including the projections, were used as provided.

The gas consumption projections for the remaining AQMA counties, including those counties served by the Montana Power Company, were assumed to be proportional to changes projected in county population. Growth factors were applied to the consumption estimates provided by the Montana Power Company.

Results of the above stated assumptions are presented in Table 4.2; the emission estimates are based on a constant emission factor used to develop the base year estimates.

Table 4.2. PROJECTIONS OF NATURAL GAS EMISSIONS

County	1974 Natural gas consumption, 10^6 cu ft	1974 Emissions, ton/yr		Growth factor	1980 Natural gas consumption, 10^6 cu ft	1980 Emissions, ton/yr		Growth factor	1985 Natural gas consumption, 10^6 cu ft	1985 Emissions, ton/yr	
		Partic	SO_2			Partic	SO_2			Partic	SO_2
Flathead	2176	10.9	0.7	1.06	2307	11.5	0.7	1.10	2538	12.7	0.8
Lake	neg	neg	neg	1.10	0	neg	neg	1.19	0	neg	neg
Missoula	3496	17.5	1.0	1.06	3706	18.5	1.1	1.12	4151	20.8	1.2
Lewis & Clark	2337	11.7	0.7	1.06	2477	12.4	0.7	1.10	2725	13.6	0.8
Deer Lodge	1086	5.4	0.3	0.96	1043	5.2	0.3	0.90	939	4.7	0.3
Silver Bow	3174	15.9	1.0	1.02	3237	16.2	1.0	1.04	3366	16.8	1.0
Yellowstone	6955	34.8	2.1	1.12	7790	39.0	2.3	1.23	9582	47.9	2.9
Carbon	210	1.0	0.1	1.06	223	1.1	0.1	1.12	235	1.2	0.1
Stillwater	59	0.3	neg	4.73	279	1.4	0.1	5.20	307	1.5	0.1
Sweetgrass	141	0.7	neg	1.03	145	0.7	neg	1.07	151	0.8	neg
Big Horn	365	1.8	0.1	1.10	401	2.0	0.1	1.26	461	2.3	0.1
Rosebud	195	1.0	0.1	1.26	246	1.2	0.1	1.54	300	1.5	0.1
Treasure	neg			1.08				1.17			
Custer	1457	7.3	0.4	1.15	1675	8.4	0.5	1.32	1927	9.6	0.6
Fallon	1153	5.8	0.3	1.03	1182	5.9	0.4	1.07	1229	6.1	0.4
Powder River	814	4.1	0.2	.17	137	0.7	neg	0.001	1	neg	neg
Carter	neg			0.95				0.90			

5. OTHER FUELS

DATA INVENTORY AND METHODOLOGY

Two types of fuels were considered in this area source category: wood and LPG. The procedure used to determine consumption for each fuel type is discussed below.

Wood - Residential wood consumption was calculated using the degree-day heating method[4] previously described in Section one, page 1-2 (eq.1). The heating requirement factor used for the tons of wood burned per dwelling unit per degree-day is 0.0017.[4] The number of degree days was determined from the closest National Weather Service (NWS) reporting station.[6] The number of dwelling units for each county used to calculate wood consumption is presented in Table 5.1. Because of the unavailability of data on residential wood burning and the small amount of emissions from this source, it was assumed that the number of 1970 dwelling units using wood[5] was representative of 1974.

There were no data available to indicate the use of wood fuel by commercial-institutional area sources. It is expected to be quite minimal. Wood burning by the industrial sources is only done by the wood industry and these industries are included as point sources. Therefore, commercial-institutional and industrial area source emissions were considered to be negligible.

LPG - The combined 1973 state commercial and residential LPG consumption was 47,702,000 gallons.[19] It was assumed that the 1973 consumption is representative of 1974. The data

Table 5.1. 1974 AREA SOURCE WOOD EMISSIONS

County	1970 DU using wood[a]	1974 Residential wood consumption, ton/yr	1974 Wood emissions, ton/yr	
			Partic	SO_2
Flathead	312	3914	19.6	2.9
Lake	412	4953	24.8	3.7
Missoula	266	3039	15.2	2.3
Lewis & Clark	116	1378	6.9	1.0
Deer Lodge	167	1854	9.3	1.4
Silver Bow	109	1266	6.3	0.9
Yellowstone	--			
Carbon	--			
Stillwater	38	419	2.1	0.3
Sweetgrass	63	695	3.5	0.5
Big Horn	14	148	0.7	0.1
Rosebud	51	516	2.6	0.4
Treasure	--			
Custer	--			
Fallon	--			
Powder River	19	211	1.1	0.2
Carter	--			

[a] Reference 5

were disaggregated into residential and commercial-institutional by using a residential to commercial-institutional ratio for natural gas consumption.[20] This ratio is 1.5 to 1. Therefore, the 1974 residential LPG consumption is approximately 28,468,000 gallons and the 1974 commercial LPG consumption is approximately 19,235,000 gallons.

Residential

Residential LPG consumption was calculated by apportioning the estimated state LPG consumption by number of dwelling units using LPG.[5] It is assumed that the ratio of county dwelling units using LPG to state dwelling units using LPG for 1974 is the same as for 1970. There were 18,503 dwelling units using LPG in 1970. These totals are presented in Table 5.2.

Commercial-Institutional

Commercial-institutional LPG consumption was calculated by apportioning the state commercial LPG consumption by county/state population. The 1974 state population is approximately 735,000.[11] The county totals are listed in Table 5.2.

Industrial

Industrial LPG consumption was calculated by apportioning state industrial LPG consumption by county/state manufacturing employees. The state industrial LPG consumption was 8,035,000 gallons[19] and was assumed to be representative of 1974. The total number of manufacturing employees in the state is 22,229.[12] Also, the 1973 ratio of the county to state manufacturing employees was assumed to be the same for 1974.

Table 5.2. 1974 AREA SOURCE LPG CONSUMPTION

County	1970 DU using LPG	1974 Residential LPG consumption, 10^3 gal/yr	1974 County population	1974 Commercial-Institutional LPG consumption, 10^3 gal/yr	1973 Manufacturing employees	1974 Industrial LPG consumption, 10^3 gal/yr
Flathead	321	494	42,600	1115	3281	1186
Lake	590	490	16,700	437	362	131
Missoula	381	586	63,700	1667	3428	1239
Lewis & Clark	639	983	36,000	942	711	257
Deer Lodge	59	90	15,100	395	30[a]	11
Silver Bow	220	338	43,200	1131	671	243
Yellowstone	780	1200	94,300	2468	3421	1237
Carbon	234	360	7,900	206	38	14
Stillwater	236	363	5,200	136	69	25
Sweetgrass	165	254	3,100	81	10[a]	4
Big Horn	683	1051	10,500	275	113	41
Rosebud	545	839	7,700	202	170	61
Treasure	70	108	1,200	31	10[a]	4
Custer	404	622	12,300	322	100	36
Fallon	195	300	3,900	102	21	8
Powder River	514	791	2,200	58	20[a]	7
Carter	447	688	1,900	50	15[a]	5

[a] Estimated from Reference 12

BASE YEAR EMISSIONS

Emissions were calculated for the two types of fuels--wood and LPG.

Wood - Applying emission factors of 10 lb/ton of wood for particulates and 1.5 lb/ton of wood for sulphur oxides yields the emissions reported in Table 5.1.[8]

LPG - The average emission factors for LPG fuel consumption are 1.9 lb/10^3 gallons for particulate and 0.9 lb/10^3 gallons for SO_2.[8] Applying these emission factors to the county total LPG consumption yields the emissions reported in Table 5.3.

PROJECTIONS

The major fuels considered in this category, as in the base year calculations, are wood and LPG. For both fuels, consumption trends are discussed for the residential, commercial-institutional, and industrial sectors.

Wood - The base year emission estimates assumed negligible consumption in the commercial-institutional sector and use in the industrial sector to be accounted for by the point source inventory. These same assumptions have been used in the projected usage. Thus, the only area source wood consumption considered is residential uses. Projections are based on county population growth, which has been assumed to be related to dwelling units using wood. These growth factors and the calculated emissions are presented in Table 5.4 (the emissions calculations assume the same factors for average annual heating degree-days and that the heating degree-day method is valid).

Table 5.3. 1974 AREA SOURCE LPG EMISSIONS

County	1974 Total LPG consumption, 10^3 gal/yr	1974 LPG Emissions, ton/yr Partic	SO_2
Flathead	2795	2.7	1.3
Lake	1476	1.4	0.7
Missoula	3492	3.3	1.6
Lewis & Clark	2182	2.1	1.0
Deer Lodge	496	0.5	0.2
Silver Bow	1712	1.6	0.8
Yellowstone	4905	4.7	2.2
Carbon	580	0.6	0.3
Stillwater	524	0.5	0.2
Sweetgrass	339	0.3	0.2
Big Horn	1367	1.3	0.6
Rosebud	1102	1.0	0.5
Treasure	143	0.1	0.1
Custer	980	0.9	0.4
Fallon	410	0.4	0.2
Powder River	856	0.8	0.4
Carter	743	0.7	0.3

TABLE 5.4. PROJECTION OF OTHER FUEL EMISSIONS-WOOD

	1974			1980			1985	
	Emissions (tons/yr)			Emissions (tons/yr)			Emissions (tons/yr)	
County	Part.	SO_2	Growth Factor	Part.	SO_2	Growth Factor	Part.	SO_2
Flathead	19.6	2.9	1.06	20.8	3.1	1.10	21.6	3.2
Lake	24.8	3.7	1.10	27.3	4.1	1.19	29.5	4.4
Missoula	15.2	2.3	1.06	16.1	2.4	1.12	17.0	2.6
Lewis & Clark	6.9	1.0	1.06	7.3	1.1	1.10	7.6	1.1
Deer Lodge	9.3	1.4	0.96	8.9	1.3	0.90	8.4	1.3
Silver Bow	6.3	0.9	1.02	6.4	0.9	1.04	6.6	0.9
Yellowstone	-	-	1.06	-	-	1.10	-	-
Carbon	-	-	1.08	-	-	1.14	-	-
Stillwater	2.1	0.3	1.08	2.3	0.3	1.15	2.4	0.3
Sweetgrass	3.5	0.5	1.03	3.6	0.5	1.07	3.8	0.5
Big Horn	0.7	0.1	1.03	0.7	0.1	1.06	0.7	0.1
Rosebud	2.6	0.4	1.17	3.0	0.5	1.30	3.4	0.5
Treasure	-	-	1.08	-	-	1.17	-	-
Custer	-	-	1.01	-	-	1.02	-	-
Fallon	-	-	0.95	-	-	0.90	-	-
Powder River	1.1	0.2	0.55	0.6	0.1	0.18	0.2	negl.
Carter	-	-	0.95	-	-	0.90	-	-

LPG - Use of LPG in the AQMA counties is not a significant source of areawide emissions, even though usage occurs in the residential, commercial-institutional, and industrial sectors. Therefore, since the total LPG consumption figures presented are relatively minor (see Tables 5.2 and 5.3), projections have been assumed proportional to county population estimates. Application of separate growth factors for each sector is unlikely to improve the accuracy of the emission estimates due to the uncertainties inherent in developing such growth factors. The projected LPG emissions are summarized in Table 5.5.

TABLE 5.5. PROJECTION OF OTHER FUEL EMISSIONS-LPG

	1974		1980			1985		
	Emissions (tons/yr)			Emissions (tons/yr)			Emissions (tons/yr)	
County	Part.	SO_2	Growth Factor	Part.	SO_2	Growth Factor	Part.	SO_2
Flathead	2.7	1.3	1.06	2.9	1.4	1.10	3.0	1.4
Lake	1.4	0.7	1.10	1.5	0.8	1.19	1.7	0.8
Missoula	3.3	1.6	1.06	3.5	1.7	1.12	3.7	1.8
Lewis & Clark	2.1	1.0	1.06	2.2	1.1	1.10	2.3	1.1
Deer Lodge	0.5	0.2	0.96	0.5	0.2	0.90	0.5	0.2
Silver Bow	1.6	0.8	1.02	1.6	0.8	1.04	1.7	0.8
Yellowstone	4.7	2.3	1.06	5.0	2.4	1.10	5.2	2.5
Carbon	0.6	0.3	1.08	0.6	0.3	1.14	0.7	0.3
Stillwater	0.5	0.2	1.08	0.5	0.2	1.15	0.6	0.2
Sweetgrass	0.3	0.1	1.03	0.3	0.1	1.07	0.3	0.1
Big Horn	1.3	0.6	1.03	1.3	0.6	1.06	1.4	0.6
Rosebud	1.0	0.5	1.17	1.2	0.6	1.30	1.3	0.7
Treasure	0.1	0.1	1.08	0.1	0.1	1.17	0.1	0.1
Custer	0.9	0.4	1.01	0.9	0.4	1.02	0.9	0.4
Fallon	0.4	0.2	0.95	0.4	0.2	0.90	0.4	0.2
Powder River	0.8	0.4	0.55	0.4	0.2	0.18	0.1	0.1
Carter	0.7	0.3	0.95	0.7	0.3	0.90	0.6	0.3

6. OPEN BURNING

DATA INVENTORY AND METHODOLOGY

There are three classifications of open burning which have been considered to estimate emissions: agricultural burning, slash burning, and forest fires. Agricultural burning includes all intentional field and ditch burning done by farmers and ranchers. Slash burning includes waste from logging operations, brush from land clearings, and brush burned in forests as a forest fire prevention method. Forest fires are self-explanatory. Data for each classification are as follows.

Agricultural Burning

The Montana Air Quality Bureau was contacted to determine the number of acres of fields burned in 1974.[21] It was the opinion of the Bureau that two percent of the planted acres of wheat, barley, and oats in each county were burned in 1974. The estimated acres of agricultural burning are listed in Table 6.1.

Slash Burning

The U.S. Forest Service was contacted to obtain data on acres of forest protected by the Forest Service in Montana and the acres of slash burned in each national forest in 1974.[22,23] The amount of slash burned in each national forest in 1974 was apportioned to each county by the number of acres in each forest.

Table 6.1. 1974 AREA SOURCE OPEN BURNING EMISSIONS

County	Agriculture, acres burned	Partic emissions, ton/yr	Slash acres burned	Forest fire acres burned	Fuel loading ton/acre	Partic emissions, ton/yr	Total Open burning partic emissions, ton/yr
Flathead	918	20	6922	648	140	9008	9028
Lake	406	9	719	16	140	875	884
Missoula	220	5	2668	446	140	3706	3711
Lewis & Clark	623	13	3840	1043	125	5188	5201
Deer Lodge	28	1	719	97	125	867	868
Silver Bow	16	neg	852	68	125	978	978
Yellowstone	2414	51	-	-	-	-	51
Carbon	821	17	124	292	110	389	406
Stillwater	1690	36	54	180	110	220	256
Sweetgrass	435	9	248	142	110	365	374
Big Horn	1795	38	-	-	-	-	38
Rosebud	763	16	31	101	110	123	139
Treasure	158	3	-	-	-	-	3
Custer	570	12	-	-	-	-	12
Fallon	1733	37	-	-	-	-	37
Powder River	849	18	116	382	110	466	484
Carter	833	18	28	90	110	110	128

The Montana Division of Forestry was contacted to determine the amount of slash burned in forests not protected by the U.S. Forest Service. An estimate of 20,000 acres of slash burned in Montana was obtained from the Division of Forestry.[24] This figure is approximately 55 percent of the figure for slash burned in forest protected by the Forest Service. Therefore, it was assumed that for each county the amount of slash burned in the forests outside the Forest Service protection boundaries was 55 percent of that burned within the protection boundaries. The total acres of slash burned in the state are reported in Table 6.1.

Forest Fires

The U.S. Forest Service provided information on the number of acres of forest consumed by forest fires in 1974 for each national forest in Montana.[25] The acres of forest consumed by forest fires in 1974 were apportioned to each county by the number of acres in each forest.

The Montana Division of Forestry provided data on forest fires outside the Forest Service protection boundaries. Forest fires occurred in six counties in 1974. Three of these counties are AQMA counties: Flathead, Missoula, and Lewis and Clark. The acres of forest consumed were apportioned by the number of acres of forest outside the Forest Service protection boundaries. The acres of forest outside the Forest Service protection boundaries were determined by subtracting the protected acres from the total land area in each county.[26]

BASE YEAR EMISSIONS

The estimated fuel loading for agricultural burning is assumed to be 2.5 tons per acre.[4] The particulate emission factor for agricultural burning is 17 pounds per ton.[8] Applying these factors to the acres burned yields the emissions listed in Table 6.1.

The U.S. Forest Service reports an estimated average fuel loading for forest in Montana of 140 tons per acre for land west of the Continental Divide and 110 tons per acre east of the Divide.[27] The particulate emission factor for forest fires is 17 pounds per ton.[8] The estimated fuel loadings and associated particulate emissions are reported in Table 6.1.

PROJECTIONS

The three categories of open burning were projected using different methodologies. The same emission factors used to compute base year emissions were assumed to be applicable for future years.

Agricultural Burning

Base year emissions from agricultural burning were estimated to be from burning of two percent of the wheat, barley, and oat crops (in planted acres) in each county. This assumption was also used for the projections in which the growth factors for planted acres of wheat, barley, and oats were determined as described below.

Data on historical and projected agricultural production (in terms of bushels harvested) are available for 1964, 1980, and 1985 from recent OBERS[15] forecasts. These data were plotted for wheat, oats, and barley and a "best fit" straight line drawn through each crop. The extrapolated graphical estimate for 1973 was compared with actual state data for 1973, available from the Montana Department of Agriculture and the U.S. Department of Agriculture Statistical Reporting Service.[28] For the three crops analyzed, an average difference of about four percent was found between the "projected vs. actual" data recorded. This slight error was judged to be acceptable for these projection purposes and the OBERS 1980 and 1985 forecasts were deemed valid.

The acreages of wheat, oats, and barley planted during 1973 in the State of Montana were similarly obtained from the Montana Agricultural Statistics.[28] Assuming constant yields per acre through 1985 (i.e., no technological advances to increase productivity per acre), it was possible to calculate future crop acreages by using the previously projected production data. This was done to yield projected acres of planted wheat, oats, and barley. Furthermore, it was assumed the base data available for 1973 were representative of 1974. Growth factors determined for 1980 and 1985 were applied to the base year estimates of acres burned in each county during 1974 to yield the summary of emissions projected shown in Table 6.2.

Slash Burning and Forest Fires

The acres of slash burned and acres consumed by forest fires is dependent on activities of the U.S. Forest Service and Montana Division of Forestry. Both categories are directly related to acreages of forest. On the one hand, although slash burning is controlled and initiated as a standard forestry management practice, it nevertheless is highly dependent on many natural phenomena (e.g., temperature, rainfall) which vary from year to year. Forest fires, on the other hand, are more unpredictable with acres consumed, in part, a function of the effectiveness of the forest fire fighters. The uncertainties associated with these two categories and near term prospects for little, if any, change in forestry management techniques led to the assumption that these two categories would remain essentially constant through 1985.

TABLE 6.2. PROJECTION OF AGRICULTURAL BURNING EMISSIONS

	1974			1980			1985	
County	Acres Burned	Part. Emissions (Tons/Yr)	Growth Factor	Acres Burned	Part. Emissions (Tons/Yr)	Growth Factor	Acres Burned	Part. Emissions (Tons/Yr)
Flathead	918	20	1.15	1,056	23	1.19	1,092	24
Lake	406	9	1.15	467	10	1.19	483	11
Missoula	220	5	1.15	253	6	1.19	262	6
Lewis & Clark	623	13	1.15	716	15	1.19	741	15
Deer Lodge	28	1	1.15	32	1	1.19	33	1
Silver Bow	16	neg	1.15	18	neg	1.19	19	neg
Yellowstone	2,414	51	1.15	2,776	59	1.19	2,873	61
Carbon	821	17	1.15	944	20	1.19	977	20
Stillwater	1,690	36	1.15	1,944	41	1.19	2,011	43
Sweetgrass	435	9	1.15	500	10	1.19	518	11
Big Horn	1,795	38	1.15	2,064	44	1.19	2,136	45
Rosebud	763	16	1.15	877	18	1.19	908	19
Treasure	158	3	1.15	182	3	1.19	188	4
Custer	570	12	1.15	656	14	1.19	678	14
Fallon	1,733	37	1.15	1,993	43	1.19	2,062	44
Powder River	849	18	1.15	976	21	1.19	1,010	21
Carter	833	18	1.15	958	21	1,19	991	21

7. HIGHWAY MOBILE SOURCES

DATA INVENTORY AND METHODOLOGY

The Montana Department of Highways provided two publications containing data on miles of road and daily vehicle miles traveled (VMT) for both rural and municipal roads.[29,30] The 1972 daily VMT data were reported for rural road systems and a few municipal systems.[29]

Additional daily VMT data were obtained for the Billings and Missoula municipal systems for 1973.[31] It was assumed that the 1973 data for Billings and Missoula municipal systems were representative of 1974. Further, it was assumed that the 1972 VMT data provided by the Department of Highways were also representative of 1974. The total daily VMT by county obtained from these two sources was then multiplied by 365 to obtain the annual county VMT totals. These totals are reported in Table 7.1.

In order to disaggregate total annual VMT into travel by light duty vehicles (LDV), light duty trucks (LDT), heavy duty gasoline powered vehicles (HDV), and heavy duty diesel powered vehicles (HDD), it was assumed that percentage of travel by vehicle type in each county was the same as the average percentages obtained for the cities of Missoula and Billings.[31] The percentage breakdown is as follows:

Vehicle type	Percent of annual VMT
Light duty vehicles (LDV)	67.0
Light duty trucks (LDT)	22.0
Heavy duty gasoline (HDV)	7.4
Heavy duty diesel (HDD)	3.6

Table 7.1. ANNUAL VEHICLE MILES TRAVELED BY VEHICLE TYPE

County	LDV 10^3 VMT	LDT 10^3 VMT	HDV 10^3 VMT	HDD 10^3 VMT	Total Annual 10^3 VMT
Flathead	217,826	71,525	24,058	11,704	325,114
Lake	96,515	31,691	10,660	5,186	144,052
Missoula	259,589	85,238	28,671	13,948	387,477
Lewis & Clark	156,161	51,277	17,248	8,391	233,076
Deer Lodge	62,397	20,489	6,892	3,353	93,130
Silver Bow	148,117	48,635	16,359	7,959	221,070
Yellowstone	334,813	109,939	36,979	17,990	499,721
Carbon	55,783	18,317	6,161	2,997	83,258
Stillwater	48,615	15,963	5,369	2,612	72,559
Sweetgrass	39,960	13,121	4,414	2,147	59,642
Big Horn	86,397	28,369	9,542	4,642	128,951
Rosebud	57,343	18,829	6,333	3,081	85,587
Treasure	16,053	5,271	1,773	863	23,959
Custer	64,900	21,311	7,168	3,487	96,866
Fallon	21,884	7,186	2,417	1,176	32,662
Powder River	20,755	6,815	2,292	1,115	30,978
Carter	13,478	4,426	1,489	724	20,116

The estimated annual vehicle miles travel by vehicle type are recorded in Table 7.1.

BASE YEAR EMISSIONS

Emission factors for LDV, LDT, HDV, and HDD for particulates and SO_2 are as follows:[8]

Pollutant	Emission factors, gm/mi LDV	LDT	HDV	HDD
Particulates				
Exhaust	.34	.34	.91	1.30
Tire wear	.20	.20	.30	.50
Brake wear	.02	.02	.03	.03
	.56	.56	1.24	1.83
SO_2	.13	.18	.36	2.80

It was assumed that HDV have an average of six tires and HDD have an average of ten tires.

Base year emissions are then calculated by multiplying VMT by the appropriate emission factor for LDV, LDT, HDV, and HDD. These emissions are listed in Table 7.2.

PROJECTIONS

Emissions of particulate matter and sulfur dioxide from highway motor vehicle exhaust were projected according to projected vehicle miles travelled in each county. The VMT projections were based on the Montana Highway Functional Classification and Needs Study--1974 Update[29] for all counties except Yellowstone and Missoula Counties, as shown in Table 7.3. The emission projection for 1980 was based solely on the VMT projection. The projection for 1985 includes an adjustment in the emission factor to account for the anticipated use of catalysts in post-1980 light duty

Table 7.2. 1974 AREA SOURCE VEHICLE EMISSIONS

County	LDV emissions, ton/yr		LDT emissions, ton/yr		HDV emissions, ton/yr		HDD emissions, ton/yr		Total emissions, ton/yr	
	Partic	SO_2	Partic	SO_2	Partic	SO_2	Partic	SO_2	Partic	SO_2
Flathead	134.3	31.2	44.1	14.2	32.9	9.5	23.6	36.1	234.9	91.0
Lake	59.5	13.8	19.5	6.3	14.6	4.2	10.5	16.0	104.1	40.3
Missoula	160.1	37.2	52.6	16.9	39.2	11.4	28.1	43.0	280.0	108.5
Lewis & Clark	96.3	22.4	31.6	10.2	23.6	6.8	16.9	25.9	168.4	65.3
Deer Lodge	38.5	8.9	12.6	4.1	9.4	2.7	6.8	10.3	67.3	26.0
Silver Bow	91.3	21.2	30.0	9.6	22.3	6.5	16.0	24.5	159.6	61.8
Yellowstone	206.5	47.9	67.8	21.8	50.5	14.7	36.3	55.5	361.1	139.9
Carbon	34.4	8.0	11.3	3.6	8.4	2.4	6.0	9.2	60.1	22.2
Stillwater	30.0	7.0	9.8	3.2	7.3	2.1	5.3	8.1	52.4	20.4
Sweetgrass	24.6	5.7	8.1	2.6	6.0	1.8	4.3	6.6	43.0	16.7
Big Horn	53.3	12.4	17.5	5.6	13.0	3.8	9.4	14.3	93.2	36.1
Rosebud	35.4	8.2	11.6	3.7	8.6	2.5	6.2	9.5	61.8	23.9
Treasure	9.9	2.3	3.3	1.0	2.4	0.7	1.7	2.7	17.3	6.7
Custer	40.0	9.3	13.1	4.2	9.8	2.8	7.0	10.8	69.9	27.1
Fallon	13.5	3.1	4.4	1.4	3.3	1.0	2.4	3.6	23.6	9.1
Powder River	12.8	3.0	4.2	1.4	3.1	0.9	2.2	3.4	22.3	8.7
Carter	8.3	1.9	2.7	0.9	2.0	0.6	1.5	2.2	14.5	5.6

TABLE 7-3 VMT PROJECTION BY COUNTY

County	1972**	1990**	Annual Percent Change	VMT Growth Factor 1974-1980	VMT Growth Factor 1974-1985
Flathead	884,468	1,549,762	3.3	1.18	1.38
Lake	389,217	666,284	3.2	1.17	1.37
Missoula*	1,176,130	2,024,144	3.2	1.17(1.37)	1.37(1.67)
Lewis & Clark	638,565	1,031,494	2.9	1.15	1.33
Deer Lodge	255,152	365,427	2.1	1.11	1.23
Silver Bow	605,671	743,900	1.2	1.06	1.13
Yellowstone*	1,593,215	2,583,728	2.9	1.15(1.47)	1.33(1.79)
Carbon	222,724	349,268	2.7	1.14	1.31
Stillwater	197,345	301,072	2.5	1.13	1.28
Sweetgrass	161,587	262,006	2.9	1.15	1.33
Big Horn	349,006	639,182	3.6	1.19	1.42
Rosebud	232,517	496,528	4.6	1.25	1.57
Treasure	65,309	100,793	2.6	1.14	1.29
Custer	265,385	356,902	1.8	1.09	1.20
Fallon	87,482	123,195	2.0	1.10	1.22
Powder River	84,247	142,559	3.1	1.16	1.36
Carter	54,826	95,060	3.3	1.18	1.38

*These growth factors were not used in Missoula or Yellowstone counties. Instead, VMT projections based on more recent data (as presented in a separate section) have been substituted, as denoted in parenthesis.

**Source: Menasco-McGuinn Associates, "Montana Highway Functional Classification and Needs Study - 1974 Update."

cars. Based on the national average,[8] these vehicles contribute approximately 50 percent of the totallight duty auto VMT, which in turn is 67 percent of the total motor vehicle VMT. The change in the particulate emission factor for these vehicles is approximately 46 percent, from 0.54 gm/mi to 0.25 gm/mi. Thus the overall change in the emission factor should be a reduction of 0.50 x 0.67 x 0.46 = 0.15, or 15 percent. The resulting emission projections are summarized in Table 7.4.

TABLE 7-4 HIGHWAY MOBILE SOURCE EMISSION PROJECTION (TONS/YR)

	1974		1980			1985		
County	Part.	SO_2	Growth Factor	Part.	SO_2	Growth Factor	Part.	SO_2
Flathead	234.9	91.0	1.18	277	107	1.38	278	127
Lake	104.1	40.3	1.17	122	47	1.37	121	55
Missoula	280.0	108.5	1.37	384	149	1.67	477	204
Lewis & Clark	168.4	65.3	1.15	194	75	1.33	190	86
Deer Lodge	67.3	26.0	1.11	75	29	1.23	71	32
Silver Bow	159.6	61.8	1.06	169	66	1.13	152	69
Yellowstone	361.1	139.9	1.47	531	206	1.79	663	302
Carbon	60.1	22.2	1.14	69	25	1.31	66	29
Stillwater	52.4	20.4	1.13	59	23	1.28	57	26
Sweetgrass	43.0	16.7	1.15	49	19	1.33	48	22
Big Horn	93.2	36.1	1.19	111	43	1.42	112	51
Rosebud	61.8	23.9	1.25	77	30	1.57	82	37
Treasure	17.3	6.7	1.14	20	8	1.29	19	9
Custer	69.9	27.1	1.09	76	30	1.20	71	32
Fallon	23.6	9.1	1.10	26	10	1.22	25	11
Powder River	22.3	8.7	1.16	26	10	1.36	26	12
Carter	14.5	5.6	1.18	17	7	1.38	17	8

8. OFF-HIGHWAY VEHICLES

DATA INVENTORY AND METHODOLOGY

This category includes off-highway vehicles using gasoline and diesel fuels. Typical gasoline fuel users are farm tractors, lawnmowers, compressors, pumps, and small electric generators. Typical diesel fuel users are farm tractors, construction equipment, and emergency generator power units.

Gasoline

To calculate gasoline fuel consumption, two fuel usage factors are used.[4]

Tractor gasoline fuel usage factor = 1,000 gal/tractor/yr

Population gasoline fuel usage factor = 13 gal/person/yr

The total number of tractors[32] and population[11] in each county are listed in Table 8.1. It is assumed that the number of tractors has increased from 1969 to 1974 by 7 percent, or in direct proportion to state-wide population growth.

Assuming that 60 percent of the tractors in each county are gasoline powered[4] and applying the tractor fuel usage factor to these tractors yields the gasoline consumption by tractors listed in Table 8.1.

Applying the population fuel usage factor to population in each county yields the gasoline consumption by other fuel users (Table 8.1).

Table 8.1. OFF-HIGHWAY GASOLINE FUEL CONSUMPTION

County	1969 Tractors	1974 Tractors	60% 1974 Gasoline	Gasoline consumption, gal/yr Tractor	Other
Flathead	1402	1500	900	900,000	553,800
Lake	1790	1915	1149	1,149,000	217,100
Missoula	566	606	364	364,000	828,100
Lewis & Clark	788	843	506	506,000	648,000
Deer Lodge	167	179	107	107,000	196,300
Silver Bow	212	220	132	132,000	561,600
Yellowstone	2634	2818	1691	1,691,000	1,225,900
Carbon	1605	1717	1030	1,030,000	102,700
Stillwater	1080	1156	694	694,000	67,600
Sweetgrass	737	789	473	473,000	40,300
Big Horn	1445	1546	928	928,000	136,500
Rosebud	972	1040	624	624,000	100,100
Treasure	417	446	268	268,000	15,600
Custer	930	995	597	597,000	159,900
Fallon	759	812	487	487,000	50,700
Powder River	931	996	598	598,000	28,600
Carter	895	958	575	575,000	24,700

Diesel

To calculate diesel fuel consumption, three fuel usage factors were used:[4]

Tractor diesel fuel usage factor = 1,000 gal/tractor/yr

Construction diesel fuel usage factor = 5,000 gal/employee/yr

Population diesel fuel usage factor = 7.4 gal/person/yr

Assuming that 35 percent of the tractors are diesel powered[4] and applying the fuel usage factor results in the diesel consumption by tractors (Table 8.2).

The total number of non-building construction employees in 1973[12] is assumed to be representative of 1974. These employees and the associated diesel consumption are listed in Table 8.2.

The 1974 population[11] and the population diesel fuel consumption in 1974 are also reported in Table 8.2.

BASE YEAR EMISSIONS

The emission factors for off-highway gasoline consumption are:[8]

	Particulates	SO_2
	($lb/10^3$ gal)	
Gasoline farm tractor	8.0	5.31
Small, general utility engines	6.21	5.22

Applying these factors to gasoline off-highway fuel consumption yields the emissions listed in Table 8.3.

Table 8.2. OFF-HIGHWAY DIESEL FUEL CONSUMPTION

County	1974 Population	Non-building employees	1974 Diesel Tractors	1974 Diesel consumption, gal/yr Tractor	Construction	Other
Flathead	42,600	218	525	525,000	1,090,000	315,240
Lake	16,700	-	670	670,000	-	123,580
Missoula	63,700	417	212	212,000	2,085,000	471,380
Lewis & Clark	36,000	460	295	295,000	2,300,000	266,400
Deer Lodge	15,100	-	63	63,000	-	111,740
Silver Bow	43,200	248	77	77,000	1,240,000	319,680
Yellowstone	94,300	849	986	986,000	4,245,000	697,820
Carbon	7,900	-	601	601,000	-	58,460
Stillwater	5,200	-	405	405,000	-	38,480
Sweetgrass	3,100	-	276	276,000	-	22,940
Big Horn	10,500	-	541	541,000	-	77,700
Rosebud	7,700	-	364	364,000	-	56,980
Treasure	1,200	-	156	156,000	-	8,880
Custer	12,300	65	348	348,000	325,000	91,020
Fallon	3,900	-	284	284,000	-	28,860
Powder River	2,200	-	349	349,000	-	16,280
Carter	1,900	-	335	335,000	-	14,060

Table 8.3. 1974 OFF-HIGHWAY EMISSIONS--GASOLINE AND DIESEL

	1974 Gasoline emissions, ton/yr				1974 Diesel emissions, ton/yr							
	Tractor		Other		Tractor		Construction		Other		Total	
County	Partic	SO_2	Partic	SO_2	Partic	SO_2	Partic	SO_2	Partic	SO_2	Partic	SO_2
Flathead	3.6	2.4	1.7	1.4	12.0	8.2	14.2	17.0	6.3	5.5	37.8	34.5
Lake	4.6	3.1	0.7	0.6	15.3	10.5	-	-	2.5	2.1	23.1	16.3
Missoula	1.5	1.0	2.6	2.2	4.8	3.3	27.2	32.5	9.5	8.2	45.6	47.2
Lewis & Clark	2.0	1.3	2.0	1.7	6.7	4.6	30.0	35.9	5.4	4.6	46.1	48.1
Deer Lodge	0.4	0.3	0.6	0.5	1.4	1.0	-	-	2.2	1.9	4.6	3.7
Silver Bow	0.5	0.4	1.7	1.5	1.8	1.2	16.2	19.3	6.4	5.5	26.6	27.9
Yellowstone	6.8	4.5	3.8	3.2	22.5	15.4	55.4	66.2	14.0	6.9	102.5	96.2
Carbon	4.1	2.7	0.3	0.3	13.7	9.4	-	-	1.2	1.0	19.3	13.4
Stillwater	2.8	1.8	0.2	0.2	9.3	6.3	-	-	0.8	0.7	13.1	9.0
Sweetgrass	1.9	1.3	0.1	0.1	6.3	4.3	-	-	0.5	0.4	8.8	6.1
Big Horn	3.7	2.5	0.4	0.4	12.4	8.4	-	-	1.6	1.3	18.1	12.6
Rosebud	2.5	1.7	0.3	0.3	8.3	5.7	-	-	1.1	0.6	12.2	8.3
Treasure	1.1	0.7	-	-	3.6	2.4	-	-	0.2	0.2	4.9	3.3
Custer	2.4	1.6	0.5	0.4	8.0	5.4	4.2	5.1	1.8	1.6	16.9	14.1
Fallon	1.9	1.3	0.2	0.1	6.5	4.4	-	-	0.6	0.5	9.2	6.3
Powder River	2.4	1.6	0.1	0.1	8.0	5.4	-	-	0.3	0.3	10.8	7.4
Carter	2.3	1.5	0.1	0.1	7.7	5.2	-	-	0.3	0.2	10.4	7.0

The emission factors for off-highway diesel consumption are:[8]

	Particulates ($lb/10^3$ gal)	SO_2
Diesel farm tractor	45.7	31.2
Diesel construction machinery	26.1	31.2
Light-duty diesel-powered vehicle	40.2	34.7

The emission factors for diesel powered construction machinery are average factors for all types of construction equipment.

There are no directly applicable emission factors for diesel fuel consumed on a per capita basis. A factor of 0.73 gm/mi for particulates and 0.63 gm/mi for SO_2 was obtained from the light duty, diesel powered vehicle emission factors.[8]

An emission factor of 40.2 $lb/10^3$ gal for particulates and 34.7 $lb/10^3$ gal for SO_2 was determined by using an average light duty vehicle fuel consumption of 25 mi/gal.[33] Applying these emission factors to the diesel fuel consumption yields the emissions listed in Table 8.3.

PROJECTIONS

Area source emissions from off-highway vehicles have been largely attributable to tractors and construction equipment. The base year emissions were estimated using parameters such as numbers of diesels and other construction equipment, amounts of diesel and gasoline consumed, and population. All of the basic methodological assumptions used in the base year have been retained for the emissions projections, including the same emission factors. Growth factors were developed from OBERS[15] projections of agricultural and contract construction economic activity (i.e., total earnings). The rationale was that since the base year emissions were primarily assigned to agricultural and construction vehicles, future growth and use of such equipment or machinery would be directly related to the economic activity of these two basic industries.

Separate projections are provided for agricultural and contract construction earnings by the three major OBERS-BEA economic areas. It was assumed that the individual county trends would follow the larger BEA economic area trends of which they were a part. Furthermore, due to the uncertainties of forecasting individual industries, a simple average of the growths/declines forecast for each industry was used as the growth factor for emissions projection. Table 8.4 presents the economic projections for 1980 and 1985 (total earnings) in terms of growth factors assuming a base year 1974 equal to 1.0. The agricultural and contract construction growths are based on actual OBERS data; the average growth factors were developed for use in the emissions estimates. Non-SMSA growth factors were used for all counties except Yellowstone. The resulting projected emissions are summarized in Table 8.5.

TABLE 8.4. ECONOMIC ACTIVITY GROWTH FACTORS

	Relative Economic Activity[1]						Average Growth Factor[2]	
	Agriculture			Contract Construction				
Economic Area	1974	1980	1985	1974	1980	1985	1980	1985
Great Falls (094)								
o BEA Region	1.0	0.98	1.01	1.0	1.15	1.29	1.07	1.15
o Non-SMSA	1.0	0.99	1.02	1.0	1.20	1.36	1.10	1.18
Billings (095)								
o BEA Region	1.0	1.05	1.08	1.0	1.20	1.34	1.13	1.21
o Non-SMSA	1.0	1.05	1.09	1.0	1.13	1.34	1.09	1.22
Butte (153)								
o BEA Region	1.0	1.03	1.04	1.0	1.11	1.24	1.07	1.14
o Non-SMSA	1.0	1.09	1.09	1.0	1.11	1.24	1.10	1.17

---

[1] Derived from basic OBERS-BEA forecasts of economic activity by industry.

[2] Developed for use in projecting emissions (Table 8.5).

TABLE 8. 5. PROJECTION OF OFF-HIGHWAY VEHICLE EMISSIONS

County	1974 Total Emissions Gasoline & Diesel (tons/yr) Part.	SO_2	Growth Factor	1980 Total Emissions Part.	SO_2	Growth Factor	1985 Total Emissions Part.	SO_2
Flathead	37.8	34.5	1.10	41.6	38.0	1.17	44.2	40.4
Lake	23.1	16.3	1.10	25.4	17.9	1.17	27.0	19.1
Missoula	45.6	47.2	1.10	50.2	51.9	1.17	53.4	55.2
Lewis & Clark	46.1	48.1	1.10	50.7	52.9	1.18	54.4	56.8
Deer Lodge	4.6	3.7	1.10	5.1	4.1	1.17	5.4	4.3
Silver Bow	26.6	27.9	1.10	29.3	30.7	1.17	31.1	32.6
Yellowstone	102.5	96.2	1.13	115.8	108.7	1.21	124.0	116.4
Carbon	19.3	13.4	1.09	21.0	14.6	1.22	23.5	16.3
Stillwater	13.1	9.0	1.09	14.3	9.8	1.22	16.0	11.0
Sweetgrass	8.8	6.1	1.09	9.6	6.6	1.22	10.7	7.4
Big Horn	18.1	12.6	1.09	19.7	13.7	1.22	22.1	15.4
Rosebud	12.2	8.3	1.09	13.3	9.0	1.22	14.9	10.1
Treasure	4.9	3.3	1.09	5.3	3.6	1.22	6.0	4.0
Carter	16.9	14.1	1.09	18.4	15.4	1.22	20.6	17.2
Fallon	9.2	6.3	1.09	10.0	6.9	1.22	11.2	7.7
Powder River	10.8	7.4	1.09	11.8	8.1	1.22	13.2	9.0
Carter	10.4	7.0	1.09	11.3	7.6	1.22	12.7	8.5

9. RAILROADS

DATA INVENTORY AND METHODOLOGY

The Montana Department of Public Service Regulation was contacted to obtain information on railroad operations in Montana.[34] A railroad route map for the railroads operating in the state was obtained, along with total track mileage by railroad in the state.[35,36,37,38]

The Burlington Northern (BN), the Milwaukee Road (MR), Butte, Anaconda and Pacific (BA&P), and Union Pacific (UP) railroads were contacted to obtain information on track mileage by county, operating days per year, frequency of trains, and the number of locomotives per train in the AQMA counties over sections of track located by use of the railroad route map.[39,40,41] The BN was unable to provide an estimate of the miles of track by county. Therefore, track mileage for BN was estimated from the railroad route map and a highway road map. The other three railroads were able to provide estimates of track mileage for the counties and these numbers were used.

A fuel factor of 2.25 gal/mi/locomotive was used to determine fuel usage by section of track.[31] This fuel factor seemed reasonable for the general terrain in Montana, and available fuel consumption information from the rail lines agreed favorably with this factor.

Table 9.1 lists the data obtained from the railroads and calculated fuel consumption.

Table 9.1. 1974 RAILROAD OPERATING DATA

Train line	Train frequency	Locomotives /train	Days of operation/yr	Miles of track	Fuel used, gal
Burlington Northern					
Flathead	14/day	3	365	102	3,518,235
	2/day	2	365	19	62,415
	1/week	1	52	9	1,053
	1/week	1	52	26	3,042
Lake	1/day	2	365	45	73,913
Missoula	7/day	3	365	60	1,034,775
	1/day	2	365	16	26,280
	1/week	1	52	20	2,340
Lewis & Clark	6/day	3	365	30	443,475
	1/day	3	365	65	160,144
	1/week	1	52	16	1,872
Deer Lodge	2/day	3	365	18	88,695
Silver Bow	2/day	3	365	31	152,753
Yellowstone	7/day	3	365	22	379,418
	6/day	3	365	23	339,998
	5/day	4	365	55	903,375
	4/day	3	365	25	246,375
	1/day	3	365	34	83,768
	1/week	1	52	20	2,340
Carbon	4/day	3	365	46	453,330
	1/week	1	52	36	4,212
	1/week	1	52	21	2,457
Stillwater	7/day	3	365	39	672,604
	1/week	1	52	19	2,223
Sweetgrass	7/day	3	365	40	698,850
Big Horn	6/day	3	365	87	1,286,078
Rosebud	21/day	4	365	23	1,586,655
	5/day	4	365	16	262,800
	4/day	3	365	29	285,795
Treasure	5/day	4	365	30	492,750
Custer	21/day	4	365	46	3,173,310

Table 9.1 (continued). 1974 RAILROAD OPERATING DATA

Train line	Train frequency	Locomotives /train	Days of operation/yr	Miles of track	Fuel used, gal
Butte, Anaconda & Pacific					
Deer Lodge	1/day	4	365	10	32,850
Silver Bow	1/day	4	365	15	49,275
Union Pacific					
Silver Bow	1/day	3	365	35	172,463
Milwaukee Road					
Missoula	2/day	3	365	60	295,650
	2/day	5	365	60	492,750
	2/day	1	313	35	49,298
	2/month	1	24	40	2,160
Deer Lodge	2/day	3	365	18	88,695
	2/day	5	365	18	147,825
	1/day	1	313	18	12,677
Silver Bow	2/day	3	365	31	152,753
	2/day	5	365	31	254,588
	1/day	1	313	31	21,832
Rosebud	4/day	3	365	96	946,080
Custer	4/day	3	365	54	532,170
Fallon	4/day	3	365	38	374,490

BASE YEAR EMISSIONS

The emission factors used to calculate particulate and SO_2 emissions are as follows:[8]

Particulate - 25 $lb/10^3$ gal
SO_2 - 57 $lb/10^3$ gal

The total fuel consumption and the calculated emissions by county are listed in Table 9.2.

PROJECTIONS

The future of railroad activity in the Montana AQMA's is tied directly to a number of uncertainties, primarily related to the future of industrial and coal development. In the case of coal, for example, future railroad activity is highly dependent upon whether the coal will be consumed in situ or whether it will be transported to Midwest sites. Further, existing capacity can be increased substantially without increasing the number of "train miles" by increasing the number of cars per train.

These considerations, together with conversations with railroad representatives[42] who were anticipating no significant changes in operations through 1985, led to the assumption that railroad emissions will remain approximately constant over the next ten years. An update of the Maintenance Plan five years hence should provide an appropriate checkpoint for this assumption.

Table 9.2. 1974 RAILROAD EMISSIONS

County	Total fuel used, all railroads, gal/yr	Emission estimates, ton/yr Partic	SO_2
Flathead	3,584,745	45	102
Lake	73,913	1	2
Missoula	1,903,253	24	54
Lewis & Clark	605,491	8	17
Deer Lodge	370,742	5	11
Silver Bow	803,664	10	23
Yellowstone	1,955,274	24	56
Carbon	459,999	6	13
Stillwater	674,827	8	19
Sweetgrass	698,850	9	20
Big Horn	1,286,078	16	37
Rosebud	3,081,330	39	88
Treasure	492,750	6	14
Custer	3,705,480	46	106
Fallon	374,490	5	11
Powder River	0	0	0
Carter	0	0	0

10. AIRCRAFT

DATA INVENTORY AND METHODOLOGY

The Montana Air Quality Bureau contacted the Federal Aviation Administration (FAA) in Helena, Montana to obtain data on airport activities at the major airports in the AQMA counties. The FAA provided information on six airports: Kalispell, Missoula, Helena, Butte, Billings, and Miles City. The airport activities were divided into four categories: common carrier, general aviation, air taxi, and military.[43] The data recorded were total take offs and landings. These totals were divided by two to obtain the number of landing-take off cycles (LTO) in each category (Table 10.1).

The Missoula Airport provided 1974 data on commercial airline landings by type of aircraft.[44] Therefore, these numbers were used to calculate emissions. To estimate the common carrier LTO cycles for the remaining airports, the Official Airline Guide[45] was used to find the number of flights into each airport every day and the type of aircraft used. Then the ratio of individual aircraft type to total aircraft was multiplied by the number of LTO cycles to obtain the number of LTO cycles by aircraft type at each airport. For example, at the Helena Airport five 727's and two 737's land every day. There were 2,381 LTO cycles for common carriers in 1974. To estimate the number of 727 landings in 1974, the following calculation was performed:

$$\frac{5}{7} \times 2381 = 1701 \quad \text{(727 LTO cycles)}$$

Table 10.1. 1974 AIRPORT LTO CYCLES

	Common carrier	General aviation	Air taxi	Military
Kalispell	1,090	23,280	550	170
Missoula	3,304	36,485	386	369
Helena	2,381	16,861	933	5,052
Butte	2,845	17,000	1,825	150
Billings	10,514	44,895	934	484
Miles City	345	17,100	250	50

There were three assumptions made pertaining to the general aviation, air taxi, and military categories:

1) Ninety percent (90%) of the general aviation LTO cycles were by one-engine piston powered aircraft, and the remainder were two-engine piston powered aircraft.

2) All air taxi LTO cycles were by two-engine piston powered aircraft.

3) Ninety-five percent (95%) of the military LTO cycles were by helicopters, and the remainder were two-engine medium range jet aircraft.[46]

The annual airport operations (LTO) for each aircraft type and each airport are summarized in Table 10.2.

BASE YEAR EMISSIONS

The emission factors for an LTO cycle are as follows for each aircraft type:[8]

	Emission factors, lb/engine	
	Partic	SO_2
Jumbo jet	1.30	1.820
Medium range jet	0.41	1.010
Air carrier turboprop	1.10	0.400
General aviation piston	0.02	0.014
Helicoptor	0.25	0.180

Multiplying the emission factor by the number of engines and annual LTO cycles yields the total emissions for each pollutant for 1974 (Table 10.3).

PROJECTIONS

Areawide projections of aircraft emissions were based primarily on anticipated increases in aircraft activity

Table 10.2. 1974 LTO CYCLES BY AIRCRAFT TYPE

Aircraft (engines)	Kalispell	Missoula	Helena	Butte	Billings	Miles City
Jumbo jet (3)					725	
Medium range jet (3)		386	680	1,264	3,626	
(2)	1,099	2,100	1,954	1,589	4,375	3
Air carrier turboprop (2)		837			1,450	345
General aviation piston (2)	2,878	4,035	2,619	3,525	5,787	1,960
(1)	20,952	32,836	15,176	15,300	40,405	15,390
Helicopter (2)	161	351	4,799	142	460	47
Total	25,090	40,545	25,228	21,820	56,828	17,745

Table 10.3. 1974 AIRCRAFT EMISSIONS
(ton/yr)

Aircraft (engines)	Kalispell		Missoula		Helena		Butte		Billings		Miles City	
	Part	SO_2	Part	SO_2	Part	SO_2	Part	SO_2	Part	SO_2	Part	SO_2
Jumbo jet									1.41	1.98		
Medium range jet (3)			0.24	0.58	0.42	1.03	0.78	1.91	2.23	5.49		
(2)	0.45	1.11	0.86	2.12	0.80	1.97	0.65	1.60	1.79	4.42	neg	neg
Air carrier turboprop			0.92	0.33					1.60	0.58	0.38	0.14
General aviation piston (2)	0.06	0.04	0.08	0.06	0.05	0.04	0.07	0.05	0.12	0.08	0.04	0.03
(1)	0.21	0.15	0.33	0.23	0.15	0.11	0.15	0.11	0.40	0.28	0.15	0.11
Helicopter	0.04	0.03	0.09	0.06	1.20	0.86	0.04	0.03	0.12	0.08	0.01	0.01
Total	0.76	1.33	2.52	3.38	2.62	4.01	1.69	3.70	7.67	12.91	0.58	0.29

through 1987. Data were obtained from the Federal Aviation Administration for 1979 and 1987.[47] These data disaggregated by type of operation are presented in Table 10.4. (Note: an LTO cycle is equivalent to two operations.) Growth factors were developed for 1980 and 1985 by linear interpolation of the base year and projected data available. These results are given in Table 10.5.

In order to project areawide emissions from the aircraft activities forecast, it was necessary to make two additional assumptions. For this analysis, it was assumed the types of aircraft in use (i.e., types of engines) would continue to be used in approximately the same ratio as in the base year. That is, no major turnover or shifts would occur in the aircraft carriers currently in use. Furthermore, it was assumed the emission factors used in developing base year emissions would remain constant through 1985. With these assumptions and the aircraft activity growth factors derived in Table 10.5, the resulting emissions were calculated and presented in Table 10.6.

TABLE 10.4. PROJECTED 1979 AND 1987 AIRCRAFT OPERATIONS[1]

	Air Carrier	Commuter	General Aviation	Military	Total	LTO Cycles[2]
Year - 1979 (Operations in Thousands)						
Kalispell	2	0	59	0	61	30.5
Missoula	9	1	88	1	99	49.5
Helena	7	3	39	15	64	32.0
Butte	6	0	37	0	43	21.5
Billings	28	2	119	2	153	76.5
Miles City	2	0	36	0	38	19.0
Year - 1987 (Operations in Thousands)						
Kalispell	4	0	120	0	124	62.0
Missoula	20	2	107	1	130	65.0
Helena	7	4	44	16	71	35.5
Butte	8	0	55	0	63	31.5
Billings	60	2	164	2	208	104.0
Miles City	4	0	46	0	50	25.0

---

[1] Data provided by local district office, Federal Aviation Administration, Helena, Montana, November 1975.

[2] One LTO cycle equal two operations.

TABLE 10.5. AIRCRAFT ACTIVITY GROWTH FACTOR-AIRPORT LTO CYCLES (000's)

Airport (County)	Airport LTO Cycles[1] 1974	 1979	 1987	Extrapolated LTO Cycles[2] 1980	 Growth Factor	 1985	 Growth Factor
Kalispell (Flathead)	25.1	30.5	62.0	34.4	1.37	54.1	2.16
Missoula (Missoula)	40.5	49.5	65.0	51.4	1.27	61.1	1.51
Helena (Lewis & Clark)	25.2	32.0	35.5	32.4	1.29	34.6	1.37
Butte (Silver Bow)	21.8	21.5	31.5	22.5	1.03	29.0	1.33
Billings (Yellowstone)	56.8	76.5	104.0	79.9	1.41	97.1	1.71
Miles City (Custer)	17.8	19.0	25.0	19.8	1.11	23.5	1.32

---

[1] Data supplied by local district office, Helena, Montana, Federal Aviation Administration, November 1975; includes common carrier, general aviation, air taxi, and military operations.

[2] Growth Factor assumes 1974 Base Year equals 1.0.

TABLE 10.6. PROJECTION OF AIRCRAFT EMISSIONS

		1974 Emissions (Tons/Yr)			1980			1985	
County	(Airport)	Part.	SO_2	Growth Factor	Part.	SO_2	Growth Factor	Part.	SO_2
Flathead	Kalispell	0.76	1.33	1.37	1.04	1.82	2.16	1.64	2.87
Missoula	Missoula	2.52	3.38	1.27	3.20	4.29	1.51	3.81	5.10
Lewis & Clark	Helena	2.62	4.01	1.29	3.38	5.17	1.37	3.59	5.49
Silver Bow	Butte	1.69	3.70	1.03	1.74	3.81	1.33	2.25	4.92
Yellowstone	Billings	7.67	12.91	1.41	10.81	18.20	1.71	13.12	22.08
Custer	Miles City	0.58	0.29	1.11	0.64	0.32	1.32	0.77	0.38

11. INDUSTRIAL PROCESSES

The categories of industrial processes to be considered are those point sources not considered in the point source emission inventory. In Montana, all sources identifiable as point sources are included in the point source emission inventory. Therefore, it was assumed that area source emissions from industrial processes were negligible in all of the AQMA counties.

12. UNPAVED ROADS

DATA INVENTORY AND METHODOLOGY

The Montana Department of Highways provided two publications containing data on unpaved roads.[29,30] County-wide mileage totals were obtained for municipal and rural roads in each surface category: unimproved, graded and drained, gravel, and paved.[30] The daily vehicle miles traveled (VMT) in 1972 over all municipal and rural roads in the local system were obtained for each county,[29] where 1972 data were assumed to be representative of 1974.

In order to calculate the VMT by surface type, it was assumed that the average daily traffic (ADT) was in a fixed ratio of 1:5:10:40. That is, there were five times as many vehicles on graded and drained roads as there were on unimproved, ten times as many vehicles on gravel roads as on unimproved, and forty times as many vehicles on paved roads as on unimproved. The following, then, is the necessary equation to arrive at ADT for each surface type:

$$\begin{aligned}\text{Daily VMT} = \text{ADT} \times \left(\begin{matrix}\text{miles of}\\ \text{unimproved}\end{matrix}\right) + 5 \times \text{ADT} \times \qquad & \text{(eq.2)}\\ \left(\begin{matrix}\text{miles of}\\ \text{graded \& drained}\end{matrix}\right) + 10 \times \text{ADT} \times & \\ \left(\begin{matrix}\text{miles of}\\ \text{gravel}\end{matrix}\right) + 40 \times \text{ADT} \times \left(\begin{matrix}\text{miles of}\\ \text{paved}\end{matrix}\right) & \end{aligned}$$

Solving for ADT, it is then possible to arrive at VMT for each surface type. The miles of road and associated daily VMT by surface type are listed in Table 12.1.

Table 12.1. 1974 MONTANA UNPAVED ROADS

	Unimproved				Graded & drained				Gravel			
	Rural		Municipal		Rural		Municipal		Rural		Municipal	
County	Miles of road	Daily VMT	Miles of road	Daily VMT	Miles of road	Daily VMT	Miles of road	Daily VMT	Miles of road	Daily VMT	Miles of road	Daily VMT
Flathead	504	3644	0	-	5	172	1.0	51	1202	86,799	16	1,800
Lake	211	1685	0	-	23	902	3.0	135	743	59,244	24	1,931
Missoula	546	4139	0	-	36	1355	18.0	1163	687	51,979	22	2,749
Lewis & Clark	374	2583	0	-	101	3498	33.0	6943	521	35,974	31	12,769
Deer Lodge	80	1045	0	-	5	309	1.0	515	84	10,981	0	0
Silver Bow	134	1164	0	-	33	1443	14.0	4309	65	5,641	6	3,917
Yellowstone	310	1846	0	-	210	6252	9.0	1071	622	36,995	34	8,213
Carbon	119	663	0	-	50	1385	5.0	131	584	32,460	8	432
Stillwater	142	594	0	-	230	4790	2.0	47	455	18,957	1	34
Sweetgrass	73	318	0	-	38	822	0.5	11	367	16,057	4	181
Big Horn	327	1965	0	-	27	809	0.4	11	600	36,073	6	343
Rosebud	424	1666	0	-	241	4732	0.3	6	599	23,550	4	138
Treasure	118	310	0	-	39	514	0.0	0	147	3,845	1	26
Custer	113	207	0	-	106	980	2.0	278	594	10,933	24	9,009
Fallon	124	452	0	-	125	2260	1.0	18	432	15,693	7	243
Powder River	187	520	0	-	109	1521	0.2	3	517	14,385	1	31
Carter	217	695	0	-	288	4607	0.0	0	185	5,908	6	195

Information on silt content of the road bases was also needed in order to estimate emissions. The percent silt on gravel road surfaces is estimated to be 12 percent, based on analytical data presented in the EPA publication, Development of Emission Factors for Fugitive Dust Sources.[48] For graded and drained or unimproved roads, no aggregate material is applied to the roadbed surface, so it is composed of compacted native soil. However, the fines originally on the surface, including silt-sized particles, are probably rapidly removed by turbulence from passing vehicles or by wind and water erosion forces. The remaining stable surface is composed of sand- and pebble-sized particles, with dust being generated primarily by the continuing mechanical breakdown of these particles as a result of traffic. It is assumed that the percent of silt-sized particles on a seasoned dirt road surface is approximately the same as that for gravel, or 12 percent.

BASE YEAR EMISSIONS

Emission factors for dust from unpaved roads were obtained from a recent EPA publication.[8]

$$E = (0.6) \times (0.81) \times (s) \times (S/30) \qquad \text{(eq.3)}$$

where E = emission factor, lb/vehicle mile
s = silt content, percent
S = average vehicle speed, mph

Assuming that the average vehicle speeds are 25 mph for unimproved roads, 30 mph for graded and drained roads, and 35 mph for gravel roads[49] produces the emission factors listed below:

Emission factors, lb/VMT	
Unimproved	4.86
Graded & drained	5.83
Gravel	6.80

These emission factors are not corrected for wet days or days with snow cover on the roads. It is assumed that no emissions occur on these days.

The number of days with 0.01 inches or more of precipitation, and the number of days with one inch or more of snow cover were estimated from the National Weather Service 1974 climatological data for the nearest recording station. The emission factors presented in Table 12.2 are corrected for non-dusting days.

To calculate emissions, the total daily VMT were multiplied by 365 to arrive at annual VMT for each surface type, then the emission factors were applied to arrive at the emissions listed in Table 12.2.

PROJECTIONS

Growth in emissions from unpaved roads is primarily a function of two factors--new miles of road and increased average daily traffic (ADT). For purposes of the projections presented, it has been assumed that the total miles of road will remain constant and that only the relative ratio of paved to unpaved roads will change. As the various communities in each county grow in population, traffic volume (or ADT) is also expected to increase. As the ADT increases, some roads will be paved, removing those roads from consideration as significant particulate emission sources. In order to incorporate these various factors into the emission projection, the following procedure was used:

Table 12.2. 1974 PARTICULATE EMISSIONS
(ton/yr)

County	Non-dusting days	Corrected emission factors, lb/VMT			Emissions, ton/yr					
		Unim-proved	Graded & drained	Gravel	Unimproved		Graded & drained		Gravel	
					Annual 10^3 VMT	Emis-sions	Annual 10^3 VMT	Emis-sions	Annual 10^3 VMT	Emis-sions
Flathead	214	2.85	3.42	3.99	1330	1895	81	139	32,339	64,516
Lake	214	2.85	3.42	3.99	615	875	379	648	22,329	44,546
Missoula	225	3.00	3.59	4.19	1511	2267	919	1650	19,976	41,850
Lewis & Clark	274	3.65	4.38	5.10	943	1721	3811	8346	17,791	45,367
Deer Lodge	274	3.65	4.38	5.10	381	695	301	659	4,008	10,220
Silver Bow	274	3.65	4.38	5.10	425	776	2099	4597	3,489	8,897
Yellowstone	250	3.33	3.99	4.66	674	1122	2673	5333	6,501	38,447
Carbon	250	3.33	3.99	4.66	242	403	553	1103	12,006	27,974
Stillwater	250	3.33	3.99	4.66	217	361	1766	3523	6,932	16,152
Sweetgrass	250	3.33	3.99	4.66	116	193	304	606	5,927	13,810
Big Horn	250	3.33	3.99	4.66	717	1194	299	597	13,292	30,970
Rosebud	240	3.20	3.83	4.47	608	973	1729	3311	8,646	19,324
Treasure	240	3.20	3.83	4.47	113	181	188	360	1,413	3,158
Custer	240	3.20	3.83	4.47	76	122	459	879	7,279	16,269
Fallon	240	3.20	3.83	4.47	165	264	831	1591	5,817	13,001
Powder River	240	3.20	3.83	4.47	190	304	556	1065	5,262	11,761
Carter	240	3.20	3.83	4.47	254	406	1682	3221	2,228	4,980

- Assume a normal distribution of ADT vs. percent of total miles of unpaved roads. This distribution is shown in Figure 12.1.
- Establish base year ADT at 50 percentile and determine percent of miles exceeding 250 vehicles per day (traffic volume at which a road is paved).
- Multiply growth factors by base year ADT to obtain projected ADT and determine percent of miles exceeding 250 vehicles per day for future years.
- Subtract base year percent of miles exceeding 250 ADT from each percent of miles determined for future years.
- Multiply this difference by the existing miles of road to arrive at additional miles of roads exceeding 250 vehicles per day, or miles which should be paved for each future year.
- Determine from the distribution the average ADT on roads to be paved for each future year (slightly greater than 250).
- Multiply this ADT by the additional miles of road exceeding 250 vehicles per day for each future year to arrive at VMT loss on unpaved roads due to paving.
- Multiply total base year VMT on unpaved roads by growth factors and subtract VMT loss due to paving.

The normal distribution of ADT vs. percent of total miles of unpaved roads was derived from an earlier study,[50] and it was assumed that the family of curves shown in Figure 12.1 could be extrapolated to cover higher values of mean ADT. The VMT growth factors were derived as shown in Table 12.3. The VMT projection from 1972 to 1990, as contained in the Montana Highway Functional Classification and Needs Study--1974 Update,[29] was used to derive annual percentage growth rates in VMT for each county. The growth rates were then used to obtain the VMT growth factors for 1980 and 1985. In the particular case of Missoula and Yellowstone

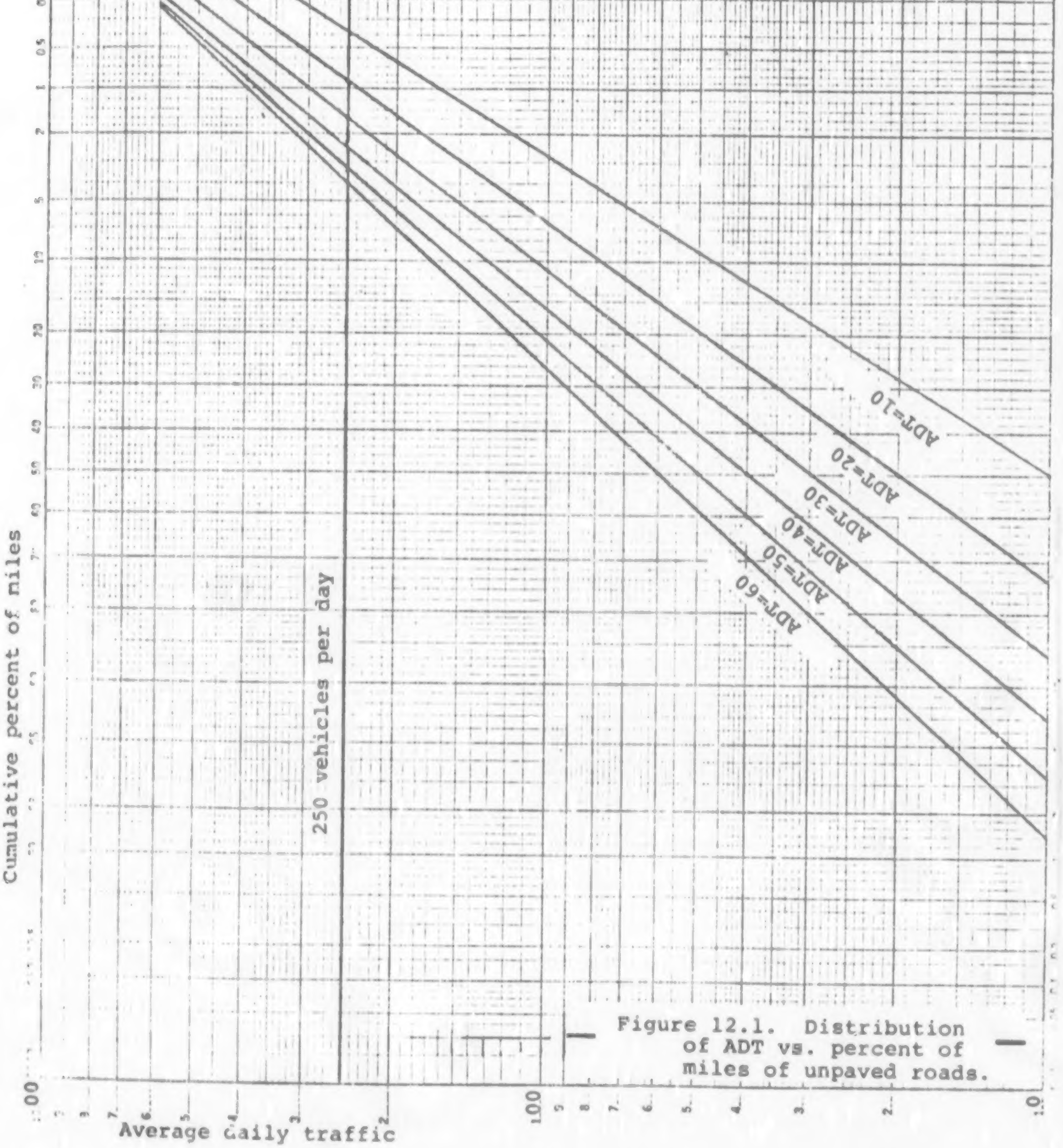

Figure 12.1. Distribution of ADT vs. percent of miles of unpaved roads.

TABLE 12-3. VMT PROJECTION BY COUNTY

County	1972**	1990**	Annual Percent Change	VMT Growth Factor 1974-1980	VMT Growth Factor 1974-1985
Flathead	884,468	1,549,762	3.3	1.18	1.38
Lake	389,217	666,284	3.2	1.17	1.37
Missoula*	1,176,130	2,024,144	3.2	1.17(1.37)	1.37(1.67)
Lewis & Clark	638,565	1,031,494	2.9	1.15	1.33
Deer Lodge	255,152	365,427	2.1	1.11	1.23
Silver Bow	605,671	743,900	1.2	1.06	1.13
Yellowstone*	1,593,215	2,583,728	2.9	1.15(1.47)	1.33(1.79)
Carbon	222,724	349,268	2.7	1.14	1.31
Stillwater	197,345	301,072	2.5	1.13	1.28
Sweetgrass	161,587	262,006	2.9	1.15	1.33
Big Horn	349,006	639,182	3.6	1.19	1.42
Rosebud	232,517	496,528	4.6	1.25	1.57
Treasure	65,309	100,793	2.6	1.14	1.29
Custer	265,385	356,902	1.8	1.09	1.20
Fallon	87,482	123,195	2.0	1.10	1.22
Powder River	84,247	142,559	3.1	1.16	1.36
Carter	54,826	95,060	3.3	1.18	1.38

*These growth factors were not used in Missoula or Yellowstone counties. Instead, VMT projections based on more recent data (as presented in a separate section) have been substituted, as denoted in parenthesis.

**Source: Menasco-McGuinn Associates, "Montana Highway Functional Classification and Needs Study - 1974 Update."

Counties, more recent VMT projection data were used in lieu of that shown in Table 12.3. These projections are described in Appendix B of this report.

The weighted average particulate matter emission factors for each county are summarized in Table 12.4, where emission factors by road surface type were weighted according to the VMT in each category in each county. Table 12.5 presents the average ADT on unpaved roads in each county. Implicit in the use of this emission factor for both base year and future year estimates is the assumption that the mix of road surface types will not substantially change over the period of the projection. This assumption is reasonable considering the small lengths of road projected to become paved.

The foregoing data were used as input to the calculation of particulate emissions from unpaved roads which are summarized by county in Table 12.6. Summary tables of the calculation for each county are continued in Appendix C of this report.

TABLE 12-4. UNPAVED ROADS PARTICULATE MATTER EMISSION FACTOR DEVELOPMENT

		Unimp. Roads		Graded & Drained		Gravel		
County	Total Unpaved Road VMT	VMT*	Emis. Factor (lbs / VMT)**	VMT*	Emis. Factor **	VMT*	Emis. Factor **	Wtd. Avg. Emis. Factor
Flathead	92,466	3,644	2.85	223	3.42	88,599	3.99	3.93
Lake	63,897	1,685	2.85	1,037	3.42	61,175	3.99	3.95
Missoula	61,385	4,139	3.00	2,518	3.59	54,728	4.19	4.08
Lewis & Clark	61,717	2,583	3.65	10,441	4.38	48,693	5.10	4.92
Deer Lodge	12,850	1,045	3.65	824	4.38	10,981	5.10	4.93
Silver Bow	16,474	1,164	3.65	5,752	4.38	9,558	5.10	4.74
Yellowstone	54,377	1,846	3.33	7,323	3.99	45,208	4.66	4.52
Carbon	35,071	663	3.33	1,516	3.99	32,892	4.66	4.61
Stillwater	24,422	594	3.33	4,837	3.99	18,991	4.66	4.49
Sweetgrass	17,389	318	3.33	833	3.99	16,238	4.66	4.60
Big Horn	39,201	1,965	3.33	820	3.99	36,416	4.66	4.58
Rosebud	30,092	1,666	3.20	4,738	3.83	23,688	4.47	4.30
Treasure	4,695	310	3.20	514	3.83	3,871	4.47	4.32
Custer	21,407	207	3.20	1,258	3.83	19,942	4.47	4.42
Fallon	18,666	452	3.20	2,278	3.83	15,936	4.47	4.36
Powder River	16,460	520	3.20	1,524	3.83	14,416	4.47	4.37
Carter	11,405	695	3.20	4,607	3.83	6,103	4.47	4.13

*From Table 12.1

**From Table 12.2

TABLE 12-5. AVERAGE ADT ON UNPAVED ROADS

County	Total Unpaved Road VMT	Total Miles Of Unpaved Roads	Average ADT
Flathead	92,466	1,728	54
Lake	63,897	1,004	64
Missoula	61,385	1,309	47
Lewis & Clark	61,717	1,060	58
Deer Lodge	12,850	170	76
Silver Bow	16,474	252	65
Yellowstone	54,377	1,185	46
Carbon	35,071	766	46
Stillwater	24,422	830	29
Sweetgrass	17,389	482	36
Big Horn	39,201	960	41
Rosebud	30,092	1,268	24
Treasure	4,695	305	15
Custer	21,407	839	26
Fallon	18,666	689	27
Powder River	16,460	814	20
Carter	11,405	696	16

TABLE 12-6. SUMMARY OF PARTICULATE EMISSIONS PROJECTIONS FROM UNPAVED ROADS (TONS/YR)

		1980		1985	
County	1974	With Paving*	Without Paving	With Paving*	Without Paving
Flathead	66, 550	73,200	78,200	80,900	91,500
Lake	46,069	51,000	53,900	53,800	63,100
Missoula	45, 767	56,000	62,900	63,500	76,700
Lewis & Clark	55,434	61,300	63,700	65,900	73,700
Deer Lodge	11,574	12,000	12,800	12,700	14,200
Silver Bow	14,270	14,800	15,000	15,200	16,100
Yellowstone	44,900	58,900	64,900	66,800	80,000
Carbon	29,480	31,900	33,600	35,000	38,700
Stillwater	20,036	20,800	22,600	20,900	25,600
Sweetgrass	14,609	15,900	16,800	18,000	19,400
Big Horn	32,761	37,300	39,000	41,300	46,600
Rosebu	23,608	28,200	29,500	33,000	37,000
Treasure	3, 699	4,200	4,300	4,600	4,800
Custer	17,270	18,500	18,800	20,000	20,700
Fallon	14, 856	16,000	16,400	17,500	18,100
Powder River	13,130	14,800	15,300	16,700	17,800
Carter	8,607	9,900	10,200	11,400	11,900

*Assumes that roads with ADT greater than 250 will be paved.

13. AGRICULTURE

DATA INVENTORY AND METHODOLOGY

There are two sources of fugitive dust from agricultural activity: windblown dust and dust generated by agricultural operations. Windblown dust was estimated by use of the windblown dust equation.[48] Dust generated by agricultural operations was determined by using the emission factor equation for agricultural tilling.[8]

The Montana Department of Agriculture was contacted to obtain data on acres planted for each crop type by county for the years 1972-73.[28] Data for 1974 were not published at the time of this analysis, so an average of the years was used to represent 1974 data.

A summary of acres planted by crop type for each county is presented in Table 13.1.

BASE YEAR EMISSIONS

The windblown dust emission factor equation for determining particulate emissions is:[48]

$$E = a \times I \times K \times C \times L' \times V' \qquad \text{(eq.4)}$$

where E = emission factor, ton/acre/yr

a = portion of total wind erosion losses that would be measured as particulates, estimated at 0.025

I = soil erodibility, ton/acre/yr

K = surface roughness factor

C = climatic factor

L' = unsheltered field width factor

V' = vegetative cover factor

Table 13.1. 1974 AGRICULTURE EMISSIONS

County & Crop type	Emission factors, ton/acre/yr I	K	C	L'	V'	E	Planted acres	Particulate emissions, ton/yr
Flathead	86		.10					
Wheat		0.6		.83	0	neg	16,950	---
Barley		0.6		.83	0	neg	26,550	---
Corn		0.6		.83	.27	.029	300	9
Oats		0.8		.90	0	neg	2,400	---
Hay		0.8		.90	0	neg	22,800	---
Alfalfa		1.0		.85	0	neg	23,150	---
Potatoes		0.8		.77	.46	.061	835	51
Lake	56		.10					
Wheat		0.6		.75	0	neg	9,150	---
Barley		0.6		.75	0	neg	8,350	---
Corn		0.6		.75	.23	.014	700	10
Oats		0.8		.80	0	neg	2,800	---
Hay		0.8		.80	0	neg	26,950	---
Alfalfa		1.0		.73	0	neg	41,050	---
Potatoes		0.8		.68	.40	.030	2,315	69
Missoula	56		.10					
Wheat		0.6		.75	0	neg	4,550	---
Barley		0.6		.75	0	neg	3,500	---
Corn		0.6		.75	.23	.014	500	7
Oats		0.8		.80	0	neg	2,950	---
Hay		0.8		.80	0	neg	8,650	---
Alfalfa		1.0		.73	0	neg	12,200	---

Table 13.1 (continued). 1974 AGRICULTURE EMISSIONS

	Emission factors, ton/acre/yr							
County & Crop type	I	K	C	L'	V'	E	Planted acres	Particulate emissions, ton/yr
Lewis & Clark	56		.25					
Wheat		0.6		.75	0	neg	12,600	---
Barley		0.6		.75	0	neg	12,950	---
Corn		0.6		.75	.35	.055	200	11
Oats		0.8		.80	0	neg	5,600	---
Hay		0.8		.80	0	neg	19,550	---
Alfalfa		1.0		.73	0	neg	22,150	---
Deer Lodge	56		.10					
Wheat		0.6		.75	0	neg	350	---
Barley		0.6		.75	0	neg	1,050	---
Hay		0.8		.80	0	neg	5,300	---
Alfalfa		1.0		.73	0	neg	7,500	---
Potatoes		0.8		.68	.40	.030	190	6
Silver Bow	56		.10					
Wheat		0.6		.75	0	neg	100	---
Barley		0.6		.75	0	neg	250	---
Oats		0.8		.80	0	neg	450	---
Hay		1.0		.80	0	neg	5,450	---
Alfalfa		0.8		.73	0	neg.	1,550	---

Table 13.1 (continued). 1974 AGRICULTURE EMISSIONS

County & Crop type	Emission factors, ton/acre/yr I	K	C	L'	V'	E	Planted acres	Particulate emissions, ton/yr
Yellowstone	47		.45					
Wheat		0.6		.72	0	neg	85,100	---
Barley		0.6		.72	0	neg	26,350	---
Corn		0.6		.72	.44	.101	11,900	1202
Oats		0.8		.77	0	neg	9,250	---
Hay		0.8		.77	0	neg	9,250	---
Alfalfa		1.0		.69	0	neg	19,200	---
Sugar beets		0.6		.56	.88	.156	10,225	1595
Beans		0.5		.53	.68	.095	1,250	119
Carbon	47		.35					
Wheat		0.6		.72	0	neg	17,950	---
Barley		0.6		.72	0	neg	19,900	---
Corn		0.6		.72	.38	.068	2,450	167
Oats		0.8		.77	0	neg	3,200	---
Hay		0.8		.77	0	neg	28,800	---
Alfalfa		1.0		.69	0	neg	32,650	---
Sugar beets		0.6		.56	.86	.119	7,070	841
Beans		0.5		.53	.66	.072	1,550	112
Stillwater	47		.40					
Wheat		0.6		.72	0	neg	48,900	---
Barley		0.6		.72	0	neg	26,950	---
Corn		0.6		.72	.41	.083	2,950	245
Oats		0.8		.77	0	neg	8,650	---
Hay		0.8		.77	0	neg	18,400	---
Alfalfa		1.0		.69	0	neg	27,100	---
Sugar beets		0.6		.56	.87	.137	960	132
Beans		0.5		.53	.67	.083	100	8

Table 13.1 (continued). 1974 AGRICULTURE EMISSIONS

	Emission factors, ton/acre/yr							
County & Crop type	I	K	C	L'	V'	E	Planted acres	Particulate emissions, ton/yr
Sweetgrass	56		.35					
Wheat		0.6		.75	0	neg	8,950	---
Barley		0.6		.75	0	neg	9,300	---
Oats		0.8		.80	0	neg	3,500	---
Hay		0.8		.80	0	neg	32,900	---
Alfalfa		1.0		.73	0	neg	27,900	---
Big Horn	47		.35					
Wheat		0.6		.72	0	neg	66,150	---
Barley		0.6		.72	0	neg	19,950	---
Corn		0.6		.72	.38	.068	11,150	758
Oats		0.8		.77	0	neg	3,650	---
Hay		0.8		.77	0	neg	25,450	---
Alfalfa		1.0		.69	0	neg	47,250	---
Beans		0.5		.53	.66	.072	1,050	76
Rosebud	47		.45					
Wheat		0.6		.72	0	neg	21,850	---
Barley		0.6		.72	0	neg	11,050	---
Corn		0.6		.72	.44	.101	5,650	571
Oats		0.8		.77	0	neg	5,250	---
Hay		0.8		.77	0	neg	7,200	---
Alfalfa		1.0		.69	0	neg	30,120	---
Sugar beets		0.6		.56	.88	.156	1,285	200
Beans		0.5		.53	.68	.095	150	14

Table 13.1 (continued). 1974 AGRICULTURE EMISSIONS

County & Crop type	Emission factors, ton/acre/yr I	K	C	L'	V'	E	Planted acres	Particulate emissions, ton/yr
Treasure	47		.45					
Wheat		0.6		.72	0	neg	4,650	---
Barley		0.6		.72	0	neg	2,250	---
Corn		0.6		.72	.44	.101	3,850	389
Oats		0.8		.77	0	neg	1,000	---
Hay		0.8		.77	0	neg	3,400	---
Alfalfa		1.0		.69	0	neg	9,400	---
Sugar beets		0.6		.56	.88	.156	3,930	613
Beans		0.5		.53	.68	.095	750	71
Custer	47		.50					
Wheat		0.6		.72	0	neg	14,850	---
Barley		0.6		.72	0	neg	8,000	---
Corn		0.6		.72	.47	.119	7,850	934
Oats		0.8		.77	0	neg	5,650	---
Hay		0.8		.77	0	neg	18,700	---
Alfalfa		1.0		.69	0	neg	16,150	---
Sugar beets		0.6		.56	.89	.176	2,395	422
Beans		0.5		.53	.69	.107	100	11
Fallon	56		.45					
Wheat		0.6		.75	0	neg	54,100	---
Barley		0.6		.75	0	neg	22,600	---
Corn		0.6		.75	.50	.142	2,250	320
Oats		0.8		.80	0	neg	9,950	---
Hay		0.8		.80	0	neg	10,250	---
Alfalfa		1.0		.73	0	neg	29,900	---

Table 13.1 (continued). 1974 AGRICULTURE EMISSIONS

County & Crop type	Emission factors, ton/acre/yr I	K	C	L'	V'	E	Planted acres	Particulate emissions, ton/yr
Powder River	47		.40					
Wheat		0.6		.72	0	neg	28,350	---
Barley		0.6		.72	0	neg	5,900	---
Corn		0.6		.72	.41	.083	300	25
Oats		0.8		.77	0	neg	8,200	---
Hay		0.8		.77	0	neg	20,550	---
Alfalfa		1.0		.69	0	neg	42,250	---
Carter	47		.45					
Wheat		0.6		.72	0	neg	23,150	---
Barley		0.6		.72	0	neg	8,650	---
Corn		0.6		.72	.44	.101	550	56
Oats		0.8		.77	0	neg	9,850	---
Hay		0.8		.77	0	neg	25,250	---
Alfalfa		1.0		.69	0	neg	34,950	---

In the equation, K, C, L', and V' are dimensionless. In the EPA fugitive dust publication,[48] the map of major soil types in the Northern Great Plain states was used to determine value I. C, K, L', and V' were also obtained from data presented in the report.

A summary of the parameters used to calculate emission factors by crop type are presented in Table 13.1. Emission factors are then multiplied by the corresponding planted acres to arrive at total annual emissions. The particulate emissions for each crop type and county are listed in Table 13.1

The agricultural tilling emission factor equation for determining particulate emissions is:[8]

$$E = \frac{1.4s}{(PE/50)^2} \qquad \text{(eq.5)}$$

where E = emission factor, lb/acre

s = silt content of surface soil, percent

PE = Thornthwaite's precipitation-evaporation index

In the equation, silt content (s) was estimated with information found on analysis of soil classes[51] and the map of major soil types in the Northern Great Plain states.[48] The agricultural tilling equation represents one pass of a tractor over each acre. It is assumed that multiplying the emission factor found in the equation by a factor of three will represent the particulate emission factor for the combined emissions of all phases of field preparation and subsequent cultivation.

For agricultural activities, 80 percent of the emissions predicted by the tilling equation are likely to remain as suspended particulates.[8] Therefore, the calculated emissions for agricultural operations were reduced by 20 percent to find the amount of suspended particulates. The values of s, PE, and the particulate emissions by county are recorded in Table 13.2.

PROJECTIONS

By assuming that the various climatic and geological (and soil) conditions remain constant in the AQMA counties (i.e., no changes in soil erodibility, surface roughness, climate, vegetative cover, silt content, etc.), the projections of agricultural particulate emissions can be reduced to a problem of projecting acreage under cultivation. While detailed historical information existed for acreages planted for the various crops by county,[28] no projections were available for the same categories of base year data.

Windblown dust emissions for the base year 1974 are summarized in Table 13.3. As seen in the table, these emissions occur primarily from four crops-corn, potatoes, sugar beets, and beans. Growth factors for projected acreages of these crops were developed from OBERS[15] state data projecting acres of cropland harvested. Separate estimates were given for feed crops including corn (also includes grain, oats, barley, and hay), and for food crops including potatoes, sugar beets, and beans (also includes wheat, rye, rice, fruits, vegetables, and sugar cane). Since the data were available for 1964, 1980, and 1985 only, a linear extrapolation was made to derive a 1974 base year estimate. These growth factors are shown in Table 13.4 by type of crop. Application of these growth factors to the base year emissions producing the future emissions are presented in Table 13.3.

Particulate emissions from agricultural operations are directly related to all agricultural tilling. In order to derive growth factors in this category, state OBERS data

Table 13.2. AGRICULTURAL OPERATIONS

County	1974 Total acres planted	Percent Silt	PE Index	E	3xE	Particulate emissions, ton/yr
Flathead	92,985	30	59	0.30	.90	33
Lake	91,315	45	59	.45	1.35	49
Missoula	32,350	45	59	.45	1.35	17
Lewis & Clark	73,050	45	46	.74	2.22	65
Deer Lodge	14,390	45	47	.71	2.13	12
Silver Bow	7,800	45	47	.71	2.13	7
Yellowstone	172,525	37	43	.70	2.10	145
Carbon	113,570	37	43	.70	2.10	95
Stillwater	134,010	37	43	.70	2.10	113
Sweetgrass	82,550	45	43	.85	2.55	84
Big Horn	174,650	37	43	.70	2.10	147
Rosebud	82,555	37	44	.67	2.01	66
Treasure	29,230	37	43	.70	2.10	25
Custer	73,695	37	44	.67	2.01	59
Fallon	129,050	45	44	.81	2.43	125
Powder River	105,550	37	44	.67	2.01	85
Carter	102,400	37	44	.67	2.01	82

TABLE 13-3. SUMMARY OF WINDBLOWN DUST AND AGRICULTURAL OPERATIONS EMISSIONS (TONS/YR) - 1974

	Windblown Dust Emissions					
County	Corn	Potato	Sugar Beets	Beans	Total Crop	Agricultural Operations Emissions
Flathead	9	51	-	-	60	33
Lake	10	69	-	-	79	49
Missoula	7	-	-	-	7	17
Lewis & Clark	11	-	-	-	11	65
Deer Lodge	-	6	-	-	6	12
Silver Bow	-	-	-	-	-	7
Yellowstone	1202	-	1595	119	2916	145
Carbon	167	-	841	112	1120	95
Stillwater	245	-	132	8	385	113
Sweet Grass	-	-	-	-	-	84
Big Horn	758	-	-	76	834	147
Rosebud	571	-	200	14	785	66
Treasure	389	-	613	71	1073	25
Custer	934	-	422	11	1367	59
Fallon	320	-	-	-	320	125
Powder River	25	-	-	-	25	85
Carter	56	-	-	-	56	82

TABLE 13-4. DEVELOPMENT OF AGRICULTURAL GROWTH FACTORS

	Growth Factors 1980	Growth Factors 1985	
Corn[1]	1.02	0.99	(Feed Crop)
Potato[1]	0.94	0.90	
Sugar Beets[1]	0.94	0.90	(Food Crop)
Beans[1]	0.94	0.90	
Total[1]	0.98[3]	0.95[3]	
Agricultural Operations[2]	0.95	0.92	

---

[1] Projected OBERS Statewide acreages for following crops available for feed and food crops; projections are for cropland harvested.

[2] Based on OBERS State projection of land used for crops and including cropland harvested, cultivated summer fallow, and failure (not including cropland used for grazing).

[3] Derived from Table 13-4.

TABLE 13-5. PROJECTIONS OF WINDBLOWN DUST EMISSIONS

County	Corn 1980	Corn 1985	Potato 1980	Potato 1985	Sugar Beets 1980	Sugar Beets 1985	Beans 1980	Beans 1985	Total Crop 1980	Total Crop 1985
Flathead	9	9	48	46	-	-	-	-	57	55
Lake	10	10	65	62	-	-	-	-	75	72
Missoula	7	7	-	-	-	-	-	-	7	7
Lewis & Clark	11	11	-	-	-	-	-	-	11	11
Deer Lodge	-	-	6	5	-	-	-	-	6	5
Silver Bow	-	-	-	-	-	-	-	-	-	-
Yellowstone	1226	1190	-	-	1499	1436	112	107	2837	2733
Carbon	170	165	-	-	791	757	105	101	1066	1023
Stillwater	250	243	-	-	124	119	8	7	382	369
Sweet Grass	-	-	-	-	-	-	-	-	-	-
Big Horn	773	750	-	-	-	-	71	68	844	818
Rosebud	582	565	-	-	188	180	13	13	783	758
Treasure	397	385	-	-	576	552	67	64	1040	1001
Custer	953	925	-	-	397	380	10	10	1360	1315
Fallon	326	317	-	-	-	-	-	-	326	317
Powder River	25	25	-	-	-	-	-	-	25	25
Carter	57	55	-	-	-	-	-	-	57	55

were used which projected total acres of land used for all crops, i.e., cropland harvested, cultivated summer fallow, and failure (cropland used only for grazing). Again, the data were only available for 1964, 1980, and 1985 and a linear extrapolation was used to develop a 1974 base year acreage estimate. These base year emissions were previously summarized in Table 13.3. The growth factors developed from the OBERS data are included in Table 13.4. Application of the growth factors to the base year emissions resulted in the projected agricultural operations emissions given in Table 13.6.

TABLE 13-6. PROJECTIONS OF AGRICULTURAL OPERATIONS EMISSIONS

County	1980 Growth Factor	1980 Emissions (Tons/Yr)	1985 Growth Factor	1985 Emissions (Tons/Yr)
Flathead	0.95	31	0.92	30
Lake	0.95	47	0.92	45
Missoula	0.95	16	0.92	16
Lewis & Clark	0.95	62	0.92	60
Deer Lodge	0.95	11	0.92	11
Silver Bow	0.95	7	0.92	6
Yellowstone	0.95	138	0.92	133
Carbon	0.95	90	0.92	87
Stillwater	0.95	107	0.92	104
Sweet Grass	0.95	80	0.92	77
Big Horn	0.95	140	0.92	135
Rosebud	0.95	63	0.92	61
Treasure	0.95	24	0.92	23
Custer	0.95	56	0.92	54
Fallon	0.95	119	0.92	115
Powder River	0.95	81	0.92	78
Carter	0.95	78	0.92	75

14. CONSTRUCTION

DATA INVENTORY AND METHODOLOGY

For purposes of estimating emissions, three different types of construction were identified: residential; commercial and public; highway. Data for the first two types of construction were obtained for the cities of Billings and Missoula as these were the two areas for which significant construction related emissions could be expected.

The acreage of residential and of commercial and public during 1974 were estimated from the number of construction permits issued for each type of construction:[52,53]

Number of construction permits, 1974

	Billings	Missoula
1 family DU	419	209
2 family DU	38	29
3 or more family DU	13	24
Commercial facility	47	36
Public facility	---	6

It was estimated that excavation and regrading exposed about 0.1 acre each for 1 and 2 family dwelling units, and 0.5 acre each for larger dwellings and for commercial facilities. Acreage for public buildings was estimated for each individual construction project. The average construction time for excavation and regrading was estimated to be four months for residential construction and six months for commercial and public construction.

The Montana Department of Highways was contacted to obtain data on highway projects constructed in 1974.[54] Acreage of highway construction was determined from the miles and width of the project, as well as the length of time that the project was under construction. It was assumed that a width of 50 feet was exposed during construction of a two lane highway and width of 150 feet was exposed during construction of a four lane highway. It was further assumed that until a project was 50 percent complete it would still be an emission source. The miles and the months of construction for each county are listed in Table 14.1.

BASE YEAR EMISSIONS

The average particulate emission factor for construction is 1.2 ton/acre/mo.[48] The following is the necessary calculation to correct this emission factor to reflect differences in climate between the test sites used to develop the emission factor and the counties in Montana:

$$E = \frac{(\text{PE test})^2}{(\text{PE county})^2} \times 1.2 \text{ ton/acre/mo} \qquad \text{(eq.6)}$$

where E = emission factor, ton/acre/mo

PE = Thornthwaite's precipitation-evaporative index

$$\text{e.g.} \quad E = \frac{(31)^2}{(59)^2} \cdot 1.2$$

$$= .33 \text{ ton/acre/mo}$$

Calculating the emission factor for each county, then applying these factors to the county construction acreage, and multiplying by the number of months yield the emissions listed in Table 14.2.

Table 14.1. 1974 HIGHWAY CONSTRUCTION

County	Length, mi	Width, ft	Acres	Months
Flathead	4.1	50	24.8	6
Missoula	1.7	150	30.9	6
	9.3	50	56.4	4
Lewis & Clark	2.5	50	15.2	4
Silver Bow	7.8	150	141.8	8
	7.9	150	143.6	7
Yellowstone	7.3	150	132.7	3
Carbon	5.8	50	35.2	7
Sweetgrass	0.7	50	4.2	6
Big Horn	3.4	50	20.6	5
Custer	6.5	50	39.4	6
Powder River	5.9	50	35.8	6

Table 14.2. 1974 AREA SOURCE CONSTRUCTION EMISSIONS

County	PE, index	E, ton/acre/mo	1974 Particulate emissions Residential, ton/yr	Commercial & public, ton/yr	Highway, ton/yr	Total Construction emissions, ton/yr
Flathead	59	.33			49.1	49.1
Lake	59	.33				
Missoula	59	.33	47.3	63.4	135.6	246.3
Lewis & Clark	46	.54			32.8	32.8
Deer Lodge	47	.52				
Silver Bow	47	.52			1112.6	1112.6
Yellowstone	43	.62	129.5	87.4	246.8	463.7
Carbon	43	.62			152.8	152.8
Stillwater	43	.62				
Sweetgrass	43	.62			15.6	15.6
Big Horn	43	.62			63.9	63.9
Rosebud	44	.60				
Treasure	43	.62				
Custer	44	.60			141.8	141.8
Fallon	44	.60				
Powder River	44	.60			128.9	128.9
Carter	44	.60				

PROJECTIONS

Projected emissions from construction were calculated by applying growth factors to the residential and the commercial and public construction. Highway construction emissions were calculated from data supplied by the State Highway Department.

Residential, Commercial and Public

Growth factors for residential and for commercial and public construction were calculated from OBERS BEA economic area projections,[15] where Billings falls in BEA economic area 095 and Missoula is within BEA economic area 153.

The indices used to determine the growth factors were "contract construction." Since no data were available for 1974, the base year factor was calculated from the 1971 historical figure and the 1980 projection figure by linear interpolation for each BEA economic area. Growth factors were then calculated for each BEA economic area and applied to the base year emissions. The following are the projected emissions for residential and for commercial and public construction:

Projected residential, commercial and public construction emissions, ton/yr

City (County)	1974 Partic emissions	Growth factor	1980 Partic emissions	Growth factor	1985 Partic emissions
Billings (Yellowstone)	216.9	1.200	260.3	1.340	290.6
Missoula (Missoula)	110.7	1.113	123.2	1.241	137.4

Highway

The Montana Highway Department provided data on projected highway construction through the fiscal year 1981,[55] with a few projects scheduled to start after 1981. It was assumed that the construction proposed for 1980 would be started during 1980 and any project scheduled after 1981 would actually be started in 1985 and that each project would be an emissions source for six months. The projected highway construction emissions are presented in Table 14.3. The emission estimates for construction are based on a constant emission factor used to develop base year emissions.

Table 14.3. PROJECTED HIGHWAY CONSTRUCTION

		1980					1985				
County	Emis Factor, ton/ac/mo	Lgth, mi	Wdth, ft	Acres	Mo	Partic emis, ton/yr	Lgth, mi	Wdth, ft	Acres	Mo	Partic emis, ton/yr
Flathead	.33	10.6	50	64.2	6	127.1	6.5	50	39.4	6	78.0
Lake	.33	5.4	50	32.7	6	64.7	-	50	-	6	-
Missoula	.33	1.2	50	7.3	6	14.5	8.8	50	53.3	6	105.5
Lewis & Clark	.54	-	50	-	6	-	0.9	50	5.5	6	17.8
Deer Lodge	.52	-	50	-	6	-	-	50	-	6	-
Silver Bow	.52	1.4	50	8.5	6	26.5	-	50	-	6	-
Yellowstone	.62	9.1	50	55.2	6	205.3	4.0	50	24.2	6	90.0
Carbon	.62	-	50	-	6	-	-	50	-	6	-
Stillwater	.62	-	50	-	6	-	4.5	50	27.3	6	101.6
Sweetgrass	.62	-	50	-	6	-	9.5	50	57.6	6	214.3
Big Horn	.62	35.4	50	214.5	6	797.9	6.5	50	39.4	6	146.6
Rosebud	.60	109.8	50	665.5	6	2395.8	-	50	-	6	-
Treasure	.62	13.0	50	78.8	6	293.1	-	50	-	6	-
Custer	.60	13.5	50	81.8	6	294.5	8.2	50	49.7	6	178.9
Fallon	.60	-	50	-	6	-	-	50	-	6	-
Powder River	.60	8.0	50	48.5	6	174.6	-	50	-	6	-
Carter	.60	-	50	-	6	-	-	50	-	6	-

15. AGGREGATE STORAGE PILES

DATA INVENTORY AND METHODOLOGY

The Montana Department of Highways provided data on the amount of stockpiled aggregate maintained by the Department for the AQMA counties in 1974.[56] The emissions from aggregate stockpiled by private industry will be considered in the 1974 point source emission inventory. Therefore, industrial aggregate storage area source emissions are assumed to be negligible. The amount of aggregate stockpiled by the Highway Department for each AQMA county is listed in Table 15.1.

BASE YEAR EMISSIONS

The particulate emission factor for estimating the total amount of dust emissions with drift potential greater than 1000 feet (particles less than 30 microns in diameter) is as follows:[48]

$$E = (0.33) \div (PE/100)^2 \qquad \text{(eq.7)}$$

where E = emission factor, pounds per ton
PE = Thornthwaite's precipitation-evaporation index

Using the map of PE values for state climatic divisions in the EPA publication,[48] it is possible to determine the PE index for the AQMA counties. These PE values and the associated emission factors are listed in Table 15.1. Applying

Table 15.1. 1974 AREA SOURCE EMISSIONS FROM AGGREGATE STORAGE PILES

County	1974 Aggregate stockpiled, tons	PE Index	Emission factor lb/ton	Particulate emissions, ton/yr
Flathead	70,843	59	0.95	33.7
Lake	70,181	59	0.95	33.3
Missoula	53,063	59	0.95	25.2
Lewis & Clark	34,663	46	1.56	27.0
Deer Lodge	10,270	47	1.49	7.7
Silver Bow	11,060	47	1.49	8.2
Yellowstone	45,258	43	1.78	40.3
Carbon	34,213	43	1.78	30.4
Stillwater	23,549	43	1.78	21.0
Sweetgrass	51,603	43	1.78	45.9
Big Horn	71,862	43	1.78	64.0
Rosebud	67,684	44	1.70	57.5
Treasure	14,746	43	1.78	13.1
Custer	27,850	44	1.70	23.7
Fallon	45,686	44	1.70	38.8
Powder River	10,604	44	1.70	9.0
Carter	67,684	44	1.70	57.5

these emission factors to the tons of aggregate stockpiled yields the particulate emissions for 1974 recorded in Table 15.1.

PROJECTIONS

As in the base year estimates, it is assumed industrial aggregate storage piles are accounted for in the point source inventory and that the only significant area source is the Montana Department of Highways. Stockpiled aggregate maintained by the Department of Highways is highly variable and related to a number of planned construction efforts. Overall, however, it is assumed the amount (or tonnages) of aggregate does not change substantially from year to year, although certain amounts may be moved about from county to county. For purposes of these projections, it is estimated these emissions will remain constant through 1985.

16. DUST FROM PAVED ROADS

DATA INVENTORY AND METHODOLOGY

Only a small amount of information is presently available on emission rates or procedures for estimating dust emissions from paved streets and highways. Various groups are currently conducting studies to obtain data on the air pollution impact of reintrained dust from roads. PEDCo recently did a particulate emission inventory of Nashville[57] in which it was assumed that these emissions are directly proportional to the amount of traffic (VMT).

The VMT data for the Montana AQMA counties have already been generated to estimate exhaust emissions and emissions from unpaved roads. The VMT on unpaved roads were subtracted from the VMT totals to obtain VMT on paved roads. These data are listed in Table 16.1.

BASE YEAR EMISSIONS

The emission factor derived for the Nashville study was 1.75 gm/VMT for those days with no precipitation. It was assumed that this factor could be applied directly to the VMT on paved roads in Montana, without taking into account days with precipitation or snow cover. The reasoning behind this assumption is that during the winter months the normal amount of loose material on road surfaces is increased substantially by periodic sanding for snow and ice control. Consequently, the emissions would be higher during those months that the sanding takes place. However, with days of precipitation and snow cover, over the course of the year

Table 16.1. EMISSIONS FROM PAVED ROADS

County	Annual 10^3 VMT paved roads	Particulate emissions, ton/yr
Flathead	291,364	562
Lake	120,730	233
Missoula	365,071	704
Lewis & Clark	210,531	406
Deer Lodge	88,440	170
Silver Bow	215,057	414
Yellowstone	479,874	925
Carbon	70,457	136
Stillwater	63,649	123
Sweetgrass	53,295	103
Big Horn	114,642	221
Rosebud	74,603	144
Treasure	22,245	43
Custer	89,052	172
Fallon	25,850	50
Powder River	24,970	48
Carter	15,953	31

the emission factor of 1.75 gm/VMT would represent a reasonably good average. The emissions calculated using this factor are recorded in Table 16.1.

PROJECTIONS

Projections of particulate emissions from paved roads were prepared under the assumption that such emissions are directly proportional to vehicle miles travelled (VMT) in each county. Thus, the base year emissions are multiplied by VMT growth factors as used in Section 12 for unpaved roads, and Section 7 for highway mobile source projections. Implicit in this assumption is the assumption that the emission factors and vehicle mixes used to develop the base year inventory will not significantly change over the next ten years. The resulting projections are summarized in Table 16.2.

TABLE 16-2. PAVED ROADS PARTICULATE EMISSION PROJECTION (TONS/YR)

County	1974	1980		1985	
		Growth Factor	Part.	Growth Factor	Part.
Flathead	562	1.18	663	1.38	783
Lake	233	1.17	273	1.37	319
Missoula	704	1.37	964	1.67	1321
Lewis & Clark	406	1.15	467	1.33	537
Deer Lodge	170	1.11	189	1.23	209
Silver Bow	414	1.06	439	1.13	465
Yellowstone	925	1.47	1360	1.79	1999
Carbon	136	1.14	155	1.31	177
Stillwater	123	1.13	139	1.28	157
Sweetgrass	103	1.15	118	1.33	136
Big Horn	221	1.19	263	1.42	313
Rosebud	144	1.25	180	1.57	225
Treasure	43	1.14	49	1.29	56
Custer	172	1.09	187	1.20	204
Fallon	50	1.10	55	1.22	61
Powder River	48	1.16	56	1.36	65
Carter	31	1.18	37	1.38	43

APPENDIX A

POPULATION PROJECTION ASSUMPTIONS

An important aspect of projecting area source emissions is determining what county population projections should be used. For Montana, the following data which were readily available and determined applicable for making projections are presented:

- Provisional county estimates for July 1, 1974 from the Bureau of the Census, Federal-State Cooperative Program Estimates. Also, from the same source, county estimates of population for 1972 and 1973.
- State OBERS projections for 1980 and 1985, using Series E population projection assumptions; these forecasts are made to the year 2020 as well, with historical data from 1950.
- State BEA economic area projections for 1980 and 1985, based on Series E population projection assumptions; these forecasts are made to the year 2020 as well, with historical data from 1950.
- Federal census data for 1970 disaggregated by county.

Local population estimates from 1971 through 1973 and the provisional 1974 estimates, based on locally obtained data, showed population growth trends substantially higher than the OBERS trends which projected a decline in both the statewide and BEA economic area population for 1980 and 1985. For this analysis, it was decided that although the local estimates for recent trends were probably more accurate (since they were based on local data), the long-term

OBERS projections should not be ignored. In order to bring recent county-wide trends more in line with the OBERS forecasts, it was assumed that the average annual growth experienced in each county from 1970-1974 would decrease by one-half through 1980 and 1985. There were also four counties which lost population from 1970 to 1974. It was assumed that these counties would continue to decline in population in a linear fashion from the average decline experienced between 1970 and 1974.

In summary, the population projections and growth factors shown in Table A are based on the following assumptions:

- Population will increase or decrease in a linear, arithmetic fashion based on mean rates of change experienced from 1970-1974.
- Counties which have increased in population from 1970-1974 will continue to increase at 50 percent of the recent arithmetic mean rate of growth.
- Counties which are declining in population will continue to decline at the same arithmetic mean rate experienced from 1970-1974.

The following population projections for the AQMA counties resulted (Table A).

TABLE A. MONTANA AQMA COUNTY POPULATION PROJECTIONS FOR 1980 AND 1985 (IN THOUSANDS)

County	1970 Census Data	1974 Pro-sional Estimates	1980 Projection	1980 Growth Factor	1985 Projection	1985 Growth Factor
Flathead	39.5	42.6	45.0	1.06	46.9	1.10
Lake	14.5	16.7	18.4	1.10	19.8	1.19
Missoula	58.3	63.7	67.8	1.06	71.3	1.12
Lewis & Clark	33.3	36.0	38.0	1.06	39.7	1.10
Deer Lodge	15.7	15.1	14.3	0.96	13.6	0.90
Silver Bow	42.0	43.2	44.1	1.02	44.9	1.04
Yellowstone	87.4	94.3	99.5	1.06	103.8	1.10
Carbon	7.1	7.9	8.5	1.08	9.0	1.14
Stillwater	4.6	5.2	5.6	1.08	6.0	1.15
Sweetgrass	3.0	3.1	3.2	1.03	3.3	1.07
Big Horn	10.1	10.5	10.8	1.03	11.1	1.06
Rosebud	7.1	7.7	9.0	1.17	10.0	1.30
Treasure	1.1	1.2	1.3	1.08	1.4	1.17
Custer	12.2	12.3	12.4	1.01	12.5	1.02
Fallon	4.1	3.9	3.7	0.95	3.5	0.90
Powder River	2.9	2.2	1.2	0.55	0.4	0.18
Carter	2.0	1.9	1.8	0.95	1.7	0.90

APPENDIX B

VEHICLE MILES TRAVELED
and
AVERAGE TRAFFIC SPEEDS

Billings, Montana

Prepared for

PEDCo - Environmental Specialists, Inc.

By

Alan M. Voorhees and Associates, Inc.
288 Clayton Street
Denver, Colorado 80206

Introduction

The Billings, Montana, area, for which vehicular travel data (VMT and travel speed) were obtained, consists of the Billings "urban area" as defined in the published comprehensive transportation plan prepared by the Montana Department of Highways. This consists of the City of Billings and the surrounding urbanized, but unincorporated, fringe area.

The Billings urban area is shown in Figure 1.

Methodology for Establishing Baseline VMT

The basis for VMT and Average Travel Speed data were obtained from the Montana Department of Highways, Bureau of Planning and Research, in Helena, Montana. Source material included the comprehensive transportation plan for Billings entitled "Billings, Montana, Urban Transportation Plan" by Clark, Coleman and Rupeiks, Inc.; and DeLeuw, Cather; April, 1969. This publication, which was based on surveys conducted in 1966, included development of a recommended 1990 highway system for Billings together with estimated 1990 traffic volumes. Also utilized was a publication entitled "Traffic by Sections," prepared by the Montana Department of Highways, Bureau of Planning and Research, containing 1973 traffic volume counts. In addition to these publications, unpublished material were obtained including 1974 "traffic by sections" and a 1973 update to the recommended plan network (prepared in April 1975), which contains estimated 1973 volumes on all the links of the Billings street and highway network.

Montana Highway Department personnel contacted in Helena, regarding the Billings VMT and speed data, included the following:

Paul DeVine, Chief, Planning and Research Bureau
Ed Donovan, Statistics Section, Planning and Research Engineer
Keenan Bingham, Urban Transportation Section, Planning and Research Bureau

A summary of the baseline VMT data compiled for Billings is given in Table 1. The footnotes in the table explain methodology and sources. The most reliable VMT estimate is the 809,300 vehicle-miles of travel for 1973. This figure was derived from a very recent (April 1975) computerized assignment of 1973 traffic to the present Billings street and highway network. It was compared with the 1966 and 1990 VMT estimates (obtained from the Billings Urban Transportation Plan) which were plotted on a graph. The 1973 calculated VMT value compared favorably with a trend line connecting the two estimated values for 1966 and 1990.

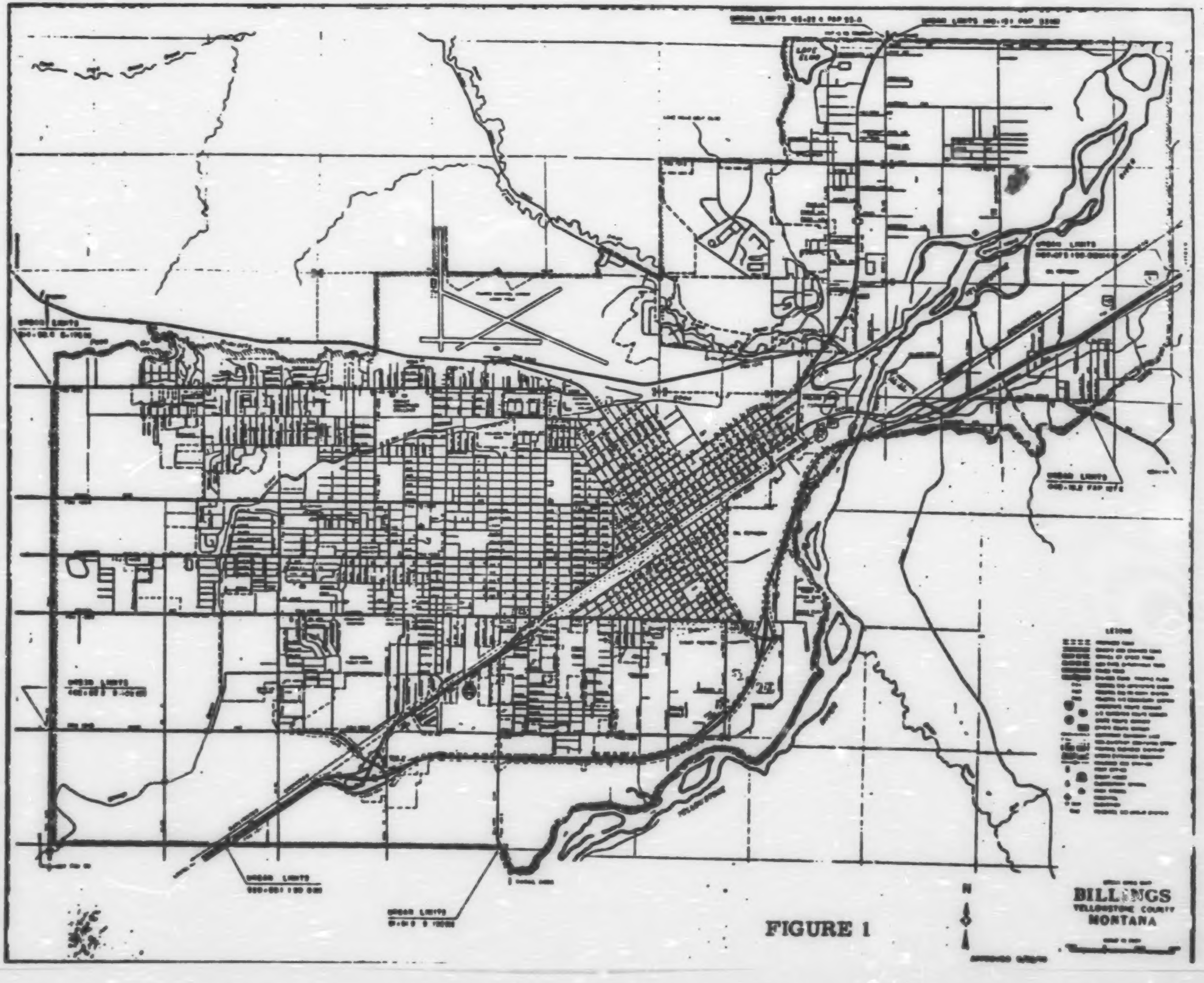
BILLINGS
YELLOWSTONE COUNTY
MONTANA
N

FIGURE 1

Table 1
ESTIMATION OF BASELINE VMT
Billings, Montana

Street and Highways	Vehicle Miles Traveled	
	1966(1)	1973-74(2)
Federal Aid Interstate	-	90,250
Federal Aid Primary	451,100	101,100
Federal Aid Secondary		9,500
Federal Aid Urban		411,800
Other Major Arterials & Collectors		196,650
Minor Collector & Local Streets	221,500(3)	
TOTALS	672,600(3)	809,300(4)

---

(1) 1966 data are estimates of VMT computed from Link Volume data contained in "Urban Transportation Plan, Billings, Montana," by Clark, Coleman and Rupeiks, Inc., April 1969

(2) 1973-1974 data for the Federal Aid Highway system are from "Traffic by Sections, Montana, 1973" by the Montana Department of Highways (supplemented by preliminary 1974 traffic-by-section data)

(3) Estimate by AMV

(4) VMT calculated for the Billings Urban Area from a 1973 Update Assignment of 1973 traffic to the Billings street and highway network. The assignment was made for the Montana Highway Department, Bureau of Planning and Research.

Table 2
COMPARISON OF TRIP GENERATION AND TRAVEL CHARACTERISTICS

Billings, Montana

ITEM	1966	1990
1. Population	77,463	149,100
2. No. of Households	24,735	46,760
3. Persons per Household	3.13	3.18
4. Total Employment	28,768	51,246
5. Vehicles Owned	30,889	81,830 **
6. Vehicles per Household	1.25	1.75 *
7. Persons per Registered Vehicle	2.51	1.82
8. Vehicle Trips Made	210,180	433,000 **
9. Trips per Person	2.58	2.90*
10. Trips per Household	8.51	9.20 **
11. Trips per Vehicle	6.8	5.3 **
12. Average Trip Length (miles)	3.2	4.0 *
13. Miles of Street System	N.A.	N.A.
14. Vehicle Miles Traveled	672,600	1,730,000 **(1)

Source: "Unstarred" data from "Urban Transportation Plan, Billings, Montana," by Clark, Coleman and Rupeiks, Inc., and DeLeuw, Cather and Associates, April 1969.

* Estimates by AMV

** Calculated by AMV

(1) A 1990 Link Volume Map for the Billings Recommended Plan showed approximately 1,477,000 VMT on the major street and highway network

VMT for 1975, 1980 and 1985

The best available information for estimating 1975, 1980 and 1985 VMT is the report, "Urban Transportation Plan, Billings, Montana," prepared in April 1969. This report summarizes 1966 and projected 1990 socio-economic data for Billings. It contains some forecasts of travel parameters. These data are summarized in Table 2. Where future travel data for 1990 was not given, AMV has estimated future travel parameters (i.e., vehicles per household, trips per person, average trip length) which allow the calculation of 1990 VMT.

Based upon 1966 and 1990 VMT estimates, plus the baseline value of 809,300 VMT for 1973, projections have been made of 1975, 1980 and 1985 VMT values. These are given in Table 3.

Table 3

PROJECTIONS OF VMT AND TRAVEL SPEEDS

Billings, Montana

	Vehicle Miles Traveled				
	1973 Baseline	1975	1980	1985	Average Travel Speed
Freeways	90,250	105,000	150,000	200,000	50mph
Arterials & Collectors	522,400	590,000	772,000	930,000	25mph
Other Streets	196,650	215,000	268,000	320,000	20mph
TOTAL	809,300	910,000	1,190,000	1,450,000	

Travel Speeds

No good data on travel speeds are available from the Billings comprehensive transportation plan. As a consequence, assumed traffic speeds of 50, 25 and 20 miles-per-hour were used respectively for freeways, arterials and collectors, and other local streets. These speeds are also shown in Table 3.

VEHICLE MILES TRAVELED
and
AVERAGE TRAFFIC SPEEDS

Missoula, Montana

Prepared for

PEDCo - Environmental Specialists, Inc.

By

Alan M. Voorhees and Associates, Inc.
288 Clayton Street
Denver, Colorado 80206

Introduction

The Missoula, Montana, area, for which vehicular travel data (VMT and travel speed) were obtained, consists of the Missoula "urban area" as defined in the published comprehensive transportation plan prepared by the Montana Department of Highways. This consists of the City of Missoula and the surrounding urbanized, but unincorporated, fringe area.

The Missoula urban area is shown in Figure 1.

Methodology for Establishing Baseline VMT

The basis for VMT and Average Travel Speed data were obtained from the Montana Department of Highways, Bureau of Planning and Research, in Helena, Montana. Source material included the comprehensive transportation plan for Missoula entitled "Missoula, Montana, Urban Transportation Plan" by Clark, Coleman and Rupeiks, Inc., October 1967. This publication, which was based on surveys conducted in 1965, included development of a recommended 1985 highway system for Missoula together with estimated 1985 traffic volumes. Also utilized was a publication entitled "Traffic by Sections," prepared by the Montana Department of Highways, Bureau of Planning and Research, containing 1973 traffic volume counts. In addition to these publications, unpublished material were obtained including 1974 "traffic by sections" and a street map of the Missoula area on which 1973 volumes for many links of the street system had been posted.

Montana Highway Department personnel contacted in Helena, regarding the Missoula VMT and speed data, included the following:

Paul DeVine, Chief, Planning and Research Bureau
Ed Donovan, Statistics Section, Planning and Research Engineer
Keenan Bingham, Urban Transportation Section, Planning and Research Bureau

A summary of the baseline VMT data compiled for Missoula is given in Table 1. The footnotes in the table explain methodology and sources. The most reliable VMT estimate is the 512,200 vehicle-miles of travel for 1973. This figure was derived from a link-by-link calculation of VMT utilizing 1973 estimates of average daily traffic and link lengths. This estimate correlates reasonably well with the approximately 370,000 vehicle miles of travel estimated for 1965, and the 853,000 vehicle miles of travel estimated for 1985 (from the Missoula Urban Transportation Plan). In other words, when the 1965 and 1985 VMT estimates were plotted, the measured 1973 value fell reasonably close to a line between the plotted values.

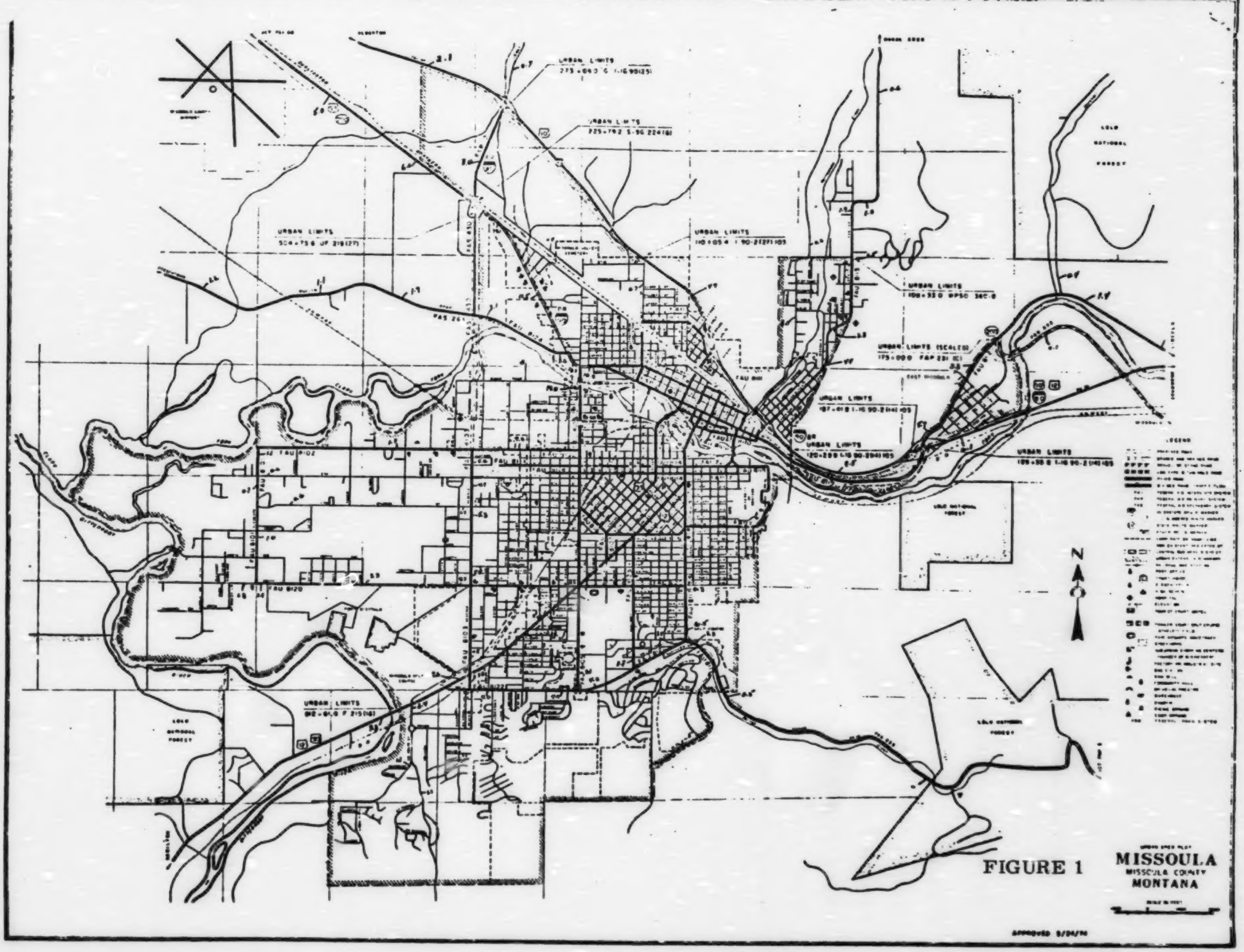MISSOULA
MISSOULA COUNTY
MONTANA
N
URBAN LIMITS
LOLO NATIONAL FOREST
LEGEND

FIGURE 1

Table 1
ESTIMATION OF BASELINE VMT
Missoula, Montana

	Vehicle Miles Traveled	
Street and Highways	1965 (1)	1973 - 74 (2)
Federal Aid Interstate	-	86,900
Federal Aid Primary	205,000	111,600
Federal Aid Secondary	84,000	6,500
Federal Aid Urban	-	172,200
Other Arterials & Collectors	54,600	80,000 (3)
Minor Collector Streets, Local Streets	28,200	55,000 (3)
TOTALS	371,800	512,200

---

(1) 1965 Data are from Table II-1, "Urban Transportation Plan, Missoula, Montana" by Clark, Coleman and Rupeiks, Inc., October 1967

(2) 1973-1974 Data are from "Traffic by Sections, Montana 1973" by the Montana Department of Highways (Supplemented by preliminary 1974 traffic by section data)

(3) Estimate by AMV

Table 2
COMPARISON OF TRIP GENERATION AND TRAVEL CHARACTERISTICS

Missoula, Montana

Item	1965	1985
1. Population	46,430	73,500
2. Number of Households	14,610	23,355
3. Persons per Household	3.18	3.15
3a. Total Employment		
4. Vehicles Owned	25,767	46,000
5. Vehicles per Household	1.76	1.97
6. Persons per Owned Vehicle	1.80	1.60
7. Vehicle Trips Made	119,924	225,269
8. Trips per Person	2.58	3.06
9. Trips per Household	8.21	9.64
10. Trips per Vehicle	4.65	4.90
11. Average Trip Length (miles)	3.1*	3.8
12. Miles of Street System	106.7 (FAP, FAS, City & County Streets)	186.9 (Recomended Plan)
13. Vehicle Miles Traveled	371,760**	853,700

*Estimated

**Calculated

Source: "Urban Transportation Plan, Missoula, Montana," Clark, Coleman and Rupeiks, Inc., October 1967

VMT for 1975, 1980 and 1985

The best available information for estimating 1975, 1980 and 1985 VMT is the report "Urban Transportation Plan, Missoula, Montana," published in October 1967. This report summarizes 1965 and projected 1985 socio-economic data for Missoula. It also contains some forecasts of travel parameters. These data are summarized in Table 2.

Based upon 1965 and 1985 VMT estimates, plus the baseline value of 512,200 VMT for 1973, projections have been made of 1975 and 1980 VMT values. These are given in Table 3.

Table 3

PROJECTIONS OF VMT AND TRAVEL SPEEDS

Missoula, Montana

	Vehicle Miles Traveled				
	1973 Baseline	1975	1980	1985	Average Travel Speed
Freeways	86,900	104,000	187,000	283,000	50mph
Arterials & Collectors	370,300	398,000	450,500	503,300	25mph
Other Streets	55,000	58,000	62,500	67,400	20mph
TOTAL	512,200	560,000	700,000	853,700	

Travel Speeds

No good data on travel speeds are available from the Missoula comprehensive transportation plan. As a consequence, assumed traffic speeds of 50, 25 and 20 miles-per-hour were used respectively for freeways, arterials and collectors, and other local streets. These speeds are shown in Table 3.

Table 4

VEHICLE MILES TRAVELED BY VEHICLE TYPE (1)
Billings and Missoula, Montana

Vehicle Miles Traveled by Vehicle Type
(In Thousands)

Urban Area	1973 (Baseline)				1975				1980				1985			
	P.C.	L.T.	H.T.	Total	P.C.	L.T.	H.T.	Total	P.C.	L.T.	H.T.	Total	P.C.	L.T.	H.T.	Total
Billings	550.3	178.0	81.0	809.3	618.8	200.0	91.2	910.0	809.0	261.0	120.0	1190.0	985.0	318.0	147.0	1450.0
Missoula	338.0	117.5	56.7	512.2	368.0	128.5	63.5	560.0	460.0	160.0	80.0	700.0	560.0	196.0	97.7	853.7

Key: P.C. - Passenger Car
L.T. - Light Truck
H.T. - Heavy Truck

Source: Montana State Department of Highways, Planning and Research Bureau and Montana State Registrar of Motor Vehicles (Registration Data for 1974)

(1) Estimates of VMT by vehicle type based upon percent of vehicle registration by vehicle type

APPENDIX C

PROJECTION OF PARTICULATE EMISSIONS FROM UNPAVED ROADS BY COUNTY

SUMMARY OF FLATHEADCOUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	1728		
Growth factor		1.18	1.38
County average ADT (unpaved roads)	54	63.72	74.52
Percent miles above 250 ADT	4	5.5	7
Percent difference from base year		1.5	3
Miles to be paved		25.9	51.8
Average ADT on miles to be paved		270	285
Daily VMT loss due to paving		6,993	14,763
Daily VMT (for total unpaved roads)	92,466	102,100	112,800
Annual Particulate Emissions with paving (tons)	66, 550	73,200	80,900
Annual Particulate Emissions without paving (tons)	66, 550	78,200	91,500

SUMMARY OF LAKE COUNTY UNPAVED ROAD EMISSION PROJECTIONS

Parameter	1974	1980	1985
Total miles of unpaved roads	1,004		
Growth factor		1.17	1.37
County average ADT (unpaved roads)	64	74.88	87.68
Percent miles above 250 ADT	5.5	7	10
Percent difference from base year		1.5	4.5
Miles to be paved		15.1	45.2
Average ADT on miles to be paved		265	285
Daily VMT loss due to paving		4,002	12,882
Daily VMT (for total unpaved roads)	63,897	70,800	74,700
Annual Particulate Emissions with paving (tons)	46,069	51,000	53,800
Annual Particulate Emissions without paving (tons)	46,069	53,900	63,100

SUMMARY OF MISSOULA COUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	1,309		
Growth factor		1.37	1.67
County average ADT (unpaved roads)	46.9	64.3	78.3
Percent miles above 250 ADT	3.5	6.0	8.0
Percent difference from base year		2.5	4.5
Miles to be paved		32.7	58.9
Average ADT on miles to be paved		280	300
Daily VMT loss due to paving		9,200	17,700
Daily VMT (for total unpaved roads)	61,385	74,900	84,800
Annual Particulate Emissions with paving (tons)	45,767	56,000	63,500
Annual Particulate Emissions without paving (tons)	45,767	62,900	76,700

SUMMARY OF LEWIS & CLARK COUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	1,060		
Growth factor		1.15	1.33
County average ADT (unpaved roads)	58	66.7	77.1
Percent miles above 250 ADT	5	6	8
Percent difference from base year		1	3
Miles to be paved		10.6	31.8
Average ADT on miles to be paved		260	275
Daily VMT loss due to paving		2,756	8,745
Daily VMT (for total unpaved roads)	61,717	68,219	73,339
Annual Particulate Emissions with paving (tons)	55,434	61,300	65,900
Annual Particulate Emissions without paving (tons)	55,434	63,700	73,700

SUMMARY OF DEER LODGE COUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	170		
Growth factor		1.11	1.23
County average ADT (unpaved roads)	76	84.4	93.5
Percent miles above 250 ADT	7	9	10.5
Percent difference from base year		2	3.5
Miles to be paved		3.4	6.0
Average ADT on miles to be paved		265	275
Daily VMT loss due to paving		901	1,650
Daily VMT (for total unpaved roads)	12,850	13,363	14,156
Annual Particulate Emissions with paving (tons)	11,574	12,000	12,700
Annual Particulate Emissions without paving (tons)	11,574	12,800	14,200

SUMMARY OF SILVER BOW COUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	252		
Growth factor		1.06	1.13
County average ADT (unpaved roads)	65	68.9	73.5
Percent miles above 250 ADT	5.5	6	7
Percent difference from base year		0.5	1.5
Miles to be paved		1.3	3.8
Average ADT on miles to be paved		255	262.5
Daily VMT loss due to paving		332	998
Daily VMT (for total unpaved roads)	16,474	17,100	17,600
Annual Particulate Emissions with paving (tons)	14,270	14,800	15,200
Annual Particulate Emissions without paving (tons)	14,270	15,000	16,100

SUMMARY OF YELLOWSTONE COUNTY (BILLINGS) UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	1,185		
Growth factor		1.47	1.79
County average ADT (unpaved roads)	45.9	67.5	82.2
Percent miles above 250 ADT	3.5	6.0	8.0
Percent difference from base year		2.5	4.5
Miles to be paved		29.6	53.3
Average ADT on miles to be paved		280	300
Daily VMT loss due to paving		8,300	16,000
Daily VMT (for total unpaved roads)	54,400	71,700	81,400
Annual Particulate Emissions with paving (tons)	44,900	58,900	66,800
Annual Particulate Emissions without paving (tons)	44,900	64,900	80,000

SUMMARY OF CARBON COUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	766		
Growth factor		1.14	1.31
County average ADT (unpaved roads)	46	52.4	60.0
Percent miles above 250 ADT	3	4	5
Percent difference from base year		1	2
Miles to be paved		7.7	15.3
Average ADT on miles to be paved		265	280
Daily VMT loss due to paving		2,040.5	4,284.0
Daily VMT (for total unpaved roads)	35,071	37,940	41,659
Annual Particulate Emissions with paving (tons)	29,480	31,900	35,000
Annual Particulate Emissions without paving (tons)	29,480	33,600	38,700

SUMMARY OF STILLWATER COUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	830		
Growth factor		1.13	1.28
County average ADT (unpaved roads)	54	61.0	69.1
Percent miles above 250 ADT	4	5	6.5
Percent difference from base year		1	2.5
Miles to be paved		8.3	20.8
Average ADT on miles to be paved		260	277.5
Daily VMT loss due to paving		2,158	5,772
Daily VMT (for total unpaved roads)	24,422	25,400	25,500
Annual Particulate Emissions with paving (tons)	20,036	20,800	20,900
Annual Particulate Emissions without paving (tons)	20,036	22,600	25,600

SUMMARY OF SWEETGRASS COUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	482		
Growth factor		1.15	1.33
County average ADT (unpaved roads)	36	41.4	47.9
Percent miles above 250 ADT	1.9	2.7	3.2
Percent difference from base year		.8	1.3
Miles to be paved		3.86	6.27
Average ADT on miles to be paved		270	277.5
Daily VMT loss due to paving		1,042.2	1,739.9
Daily VMT (for total unpaved roads)	17,389	18,955	21,387
Annual Particulate Emissions with paving (tons)	14,609	15,900	18,000
Annual Particulate Emissions without paving (tons)	14,609	16,800	19,400

SUMMARY OF BIG HORN COUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	960		
Growth factor		1.19	1.42
County average ADT (unpaved roads)	41	48.8	58.4
Percent miles above 250 ADT	2.7	3.5	5
Percent difference from base year		.8	2.3
Miles to be paved		7.7	22.1
Average ADT on miles to be paved		265	285
Daily VMT loss due to paving		2,041	6,299
Daily VMT (for total unpaved roads)	39,201	44,600	49,400
Annual Particulate Emissions with paving (tons)	32,761	37,300	41,300
Annual Particulate Emissions without paving (tons)	32,761	39,000	46,600

SUMMARY OF ROSEBUD COUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	1,268		
Growth factor		1.25	1.57
County average ADT (unpaved roads)	24	30	37.6
Percent miles above 250 ADT	1.1	1.6	2.5
Percent difference from base year		.5	1.4
Miles to be paved		6.3	17.8
Average ADT on miles to be paved		270	290
Daily VMT loss due to paving		1,701	5,162
Daily VMT (for total unpaved roads)	30,092	35,900	42,000
Annual Particulate Emissions with paving (tons)	23,608	28,200	33,000
Annual Particulate Emissions without paving (tons)	23,608	29,500	37,000

SUMMARY OF TREASURE COUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	305		
Growth factor		1.14	1.29
County average ADT (unpaved roads)	15	17.10	19.39
Percent miles above 250 ADT	0.6	0.7	0.8
Percent difference from base year		0.1	0.2
Miles to be paved		.31	.61
Average ADT on miles to be paved		255	260
Daily VMT loss due to paving		79	159
Daily VMT (for total unpaved roads)	4,695	5,273	5,898
Annual Particulate Emissions with paving (tons)	3,699	4,200	4,600
Annual Particulate Emissions without paving (tons)	3,699	4,200	4,800

SUMMARY OF CUSTER COUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	839		
Growth factor		1.09	1.20
County average ADT (unpaved roads)	26	28.34	31.2
Percent miles above 250 ADT	1.2	1.4	1.6
Percent difference from base year		.2	.4
Miles to be paved		1.7	3.4
Average ADT on miles to be paved		255	265
Daily VMT loss due to paving		433.5	901
Daily VMT (for total unpaved roads)	21,407	22,900	24,800
Annual Particulate Emissions with paving (tons)	17,270	18,500	20,000
Annual Particulate Emissions without paving (tons)	17,270	18,800	20,700

SUMMARY OF FALLON COUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	689		
Growth factor		1.10	1.22
County average ADT (unpaved roads)	27	29.7	32.9
Percent miles above 250 ADT	1.4	1.6	1.8
Percent difference from base year		0.2	0.4
Miles to be paved		1.38	2.76
Average ADT on miles to be paved		255	265
Daily VMT loss due to paving		351.9	731.4
Daily VMT (for total unpaved roads)	18,666	20,200	22,000
Annual Particulate Emissions with paving (tons)	14,856	16,000	17,500
Annual Particulate Emissions without paving (tons)	14,856	16,400	18,100

SUMMARY OF POWDER RIVER COUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	814		
Growth factor		1.16	1.36
County average ADT (unpaved roads)	20	23.2	27.2
Percent miles above 250 ADT	0.8	1.1	1.4
Percent difference from base year		0.3	0.6
Miles to be paved		2.4	4.9
Average ADT on miles to be paved		265	280
Daily VMT loss due to paving		636	1,372
Daily VMT (for total unpaved roads)	16,460	18,500	21,000
Annual Particulate Emissions with paving (tons)	13,130	14,800	16,700
Annual Particulate Emissions without paving (tons)	13,130	15,300	17,800

SUMMARY OF CARTER COUNTY UNPAVED ROAD EMISSION PROJECTION

Parameter	1974	1980	1985
Total miles of unpaved roads	696		
Growth factor		1.18	1.38
County average ADT (unpaved roads)	16	18.9	22.1
Percent miles above 250 ADT	0.65	0.8	1.0
Percent difference from base year		0.15	0.35
Miles to be paved		1.04	2.44
Average ADT on miles to be paved		260	270
Daily VMT loss due to paving		270.4	658.8
Daily VMT (for total unpaved roads)	11,405	13,200	15,100
Annual Particulate Emissions with paving (tons)	8,607	9,900	11,400
Annual Particulate Emissions without paving (tons)	8,607	10,200	11,900

REFERENCES

1. Communication with Bud Richt. B & B Farm and Wholesale Supply Company, Hamilton, Montana. September 1975.
2. Communication with Carol Tompkins. Pioneer Concrete & Fuel, Incorporated, Butte, Montana. September 1975.
3. Communication with Divide Coal Company, Roundup, Montana. September 1975.
4. Guide for Compiling a Comprehensive Emission Inventory, Second Edition. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. Publication Number APTD-1135. December 1974.
5. The 1970 Census of Housing, Montana Detailed Housing Characteristics. U.S. Department of Commerce, Bureau of the Census, Washington, D.C. 1970.
6. Local Climatological Data, Monthly Summaries and Annual Summaries. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Center, Asheville, North Carolina. 1974.
7. Mineral Industry Surveys, Bituminous Coal and Lignite Distribution. U.S. Department of the Interior, Bureau of Mines, Washington, D.C. 1974.
8. Compilation of Air Pollutant Emission Factors, Supplements 1 through 5. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. Publication Number AP-42. April 1975.
9. Communication with W. P. Schmeckel. Western Energy Company, Butte, Montana. September 1975.
10. Mineral Industry Surveys, Sales of Fuel Oil and Kerosene in 1973. U.S. Department of the Interior, Bureau of Mines, Washington, D.C. 1974.
11. Montana Current Population Reports, Federal-State Cooperative Program for Population Estimates. U.S. Department of Commerce, Bureau of the Census, Washington, D.C. Series P-26. 1974.
12. Montana County Business Patterns. U.S. Department of Commerce, Bureau of the Census, Washington, D.C. 1973.
13. National Emission Data System (NEDS), State of Montana Computer Listing. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. May 1975.

14. Wyoming Area Source Emission Inventory. PEDCo-Environmental Specialists, Inc., Cincinnati, Ohio. EPA Contract Number 68-02-1375. June 1975.

15. The 1972 OBERS Projections, Regional Economic Activity in the United States, Series E Population. U.S. Water Resources Council, Washington, D.C. Volumes I and IV. April 1974.

16. Population and Economic Activity in the United States and Standard Metropolitan Statistical Areas. U.S. Environmental Protection Agency. U.S. Department of Housing and Urban Development. July 1972.

17. Data provided by Carl R. Andersen, Manager, Department of Environmental Protection. The Montana Power Company, Butte, Montana. September 1975.

18. Data provided by A. J. Mayer, Manager, Gas Distribution. Montana-Dakota Utilities Company, Bismarck, North Dakota. August 1975.

19. Mineral Industry Surveys, Sales of Liquefied Petroleum Gases and Ethane. U.S. Department of the Interior, Bureau of Mines, Washington, D.C. 1973.

20. Mineral Industry Surveys, Natural Gas Production and Consumption in 1973. U.S. Department of the Interior, Bureau of Mines, Washington, D.C. 1974.

21. Communication with Clark Nielson. Montana Air Quality Bureau, Helena, Montana. September 1975.

22. 1974 Fall Burning. U.S. Forest Service, U.S. Department of Agriculture, Region 1, Missoula, Montana. January 1975.

23. Communication with Carol Cameron. U.S. Forest Service, U.S. Department of Agriculture, Missoula, Montana. May and July 1975.

24. Communication with Ralph Hansen, Superintendent of Suppression Section. Montana Division of Forestry, Department of Natural Resources and Conservation, Missoula, Montana. October 1975.

25. Communication with Ron Hendickson, Assistant Regional Coordinator. U.S. Forest Service, U.S. Department of Agriculture, Missoula, Montana. October 1975.

26. County and City Data Book--A Statistical Abstract Supplement. U.S. Department of Commerce, Bureau of the Census, Washington, D.C. 1975.

27. Communication with Clark Nielson, Montana Air Quality Bureau, Helena, Montana. Data acquired from U.S. Forest Service, U.S. Department of Agriculture. May 1975.

28. Montana Agricultural Statistics, County Statistics 1972 and 1973. Montana Department of Agriculture and Statistical Reporting Service and U.S. Department of Agriculture. Volume XV. December 1974.

29. Montana Highway Functional Classification and Needs Study--1974 Update. Menasco-McGuinn Associates, Helena, Montana. June 1974.

30. Federal Aid Road Log, Montana. 1974.

31. Traffic Study for Billings and Missoula, Montana. Alan M. Voorhees and Associates, Denver, Colorado. June 1975. (Included as Appendix B of this report.)

32. Census of Agriculture, County Data. U.S. Department of Commerce, Bureau of the Census, Washington, D.C. 1969.

33. Communication with salesman. Heshion Motors, Incorporated, Kansas City, Missouri. September 1975.

34. Communication with Bruce Tombs, Assistant Administrator, Transportation Division. Montana Department of Public Service Regulation, Helena, Montana. July 1975.

35. Annual Report to the Montana Public Service Commission. Burlington Northern Railroad, Incorporated, St. Paul, Minnesota. 1975.

36. Annual Report to the Montana Public Service Commission. Chicago, Milwaukee, St. Paul and Pacific Railroad (The Milwaukee Road), Chicago, Illinois. 1975.

37. Annual Report to the Montana Public Service Commission. Butte, Anaconda and Pacific Railroad, Anaconda, Montana. 1975.

38. Annual Report to the Montana Public Service Commission. Union Pacific Railroad Company, New York, New York. 1975.

39. Communication with Norm Koplin, Manager, Trains and Terminals. Burlington Northern Railroad, Billings, Montana. August 1975.

40. Communication with S. O. Jones, Superintendent. Milwaukee Road, Deer Lodge, Montana. August 1975.

41. Communication with Howard Goodfellow, General Traffic Agent. Butte, Anaconda and Pacific Railroad, Butte, Montana. August 1975.

42. Personal communication with L. Kelly, Butte, Anaconda and Pacific Railroad and H. Goodfellow, Union Pacific Railroad. November 21, 1975.

43. Communication with Wayne Flaherty. Federal Aviation Administration, Helena, Montana. July 1975.

44. Communication with Dalton F. Sessions, Chief, Missoula Tower. Airport Traffic Control Tower, Missoula, Montana. July 1975.

45. Official Airline Guide, North American Edition. Reuben H. Donnelley, Oak Brook, Illinois. June 1975.

46. Communication with Airport Manager's Office. Billings Airport, Billings, Montana. May 1975.

47. Personal communication with Wayne Flaherty, Planning Director, Airport District Office. Federal Aviation Administration, Helena, Montana. November 1975.

48. Development of Emission Factors for Fugitive Dust Sources. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. Publication Number EPA-450/3-74-037. June 1974.

49. North Dakota Traffic Report, 1973. North Dakota State Highway Department, Planning and Research and U.S. Department of Transportation, Federal Highway Administration, Bismarck, North Dakota. 1974.

50. Investigation of Fugitive Dust Sources, Emissions, and Control for Attainment of Secondary Ambient Air Quality Standards--Colorado. Prepared by PEDCo-Environmental Specialists, Inc., Cincinnati, Ohio for U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. November 1973.

51. Buckman, Harry O., Nyle C. Brady. The Nature and Properties of Soils. Seventh Edition. New York, Macmillan, 1974.

52. Fugitive Dust Emission Inventory. Yellowstone County Air Pollution Control Agency, Billings, Montana. May 1975.

53. Communication with Joan Good, Building Inspector's Office. City of Missoula, Missoula, Montana. November 1975.

54. Monthly Construction Reports--January through December, 1974. Montana Department of Highways, Construction Bureau, Helena, Montana. 1974.

55. Tentative Construction Program, Fiscal Years 1976, 1977, 1978, 1979, 1980, 1981. Montana Department of Highways, Helena, Montana. October 1975.

56. Communication with Francis U. Toombs, Assistant Administrator, Maintenance Division. Montana Department of Highways. September 1975.

57. Particulate Area Source Emission Inventory for Nashville-Davidson County, Tennessee. PEDCo-Environmental Specialists, Inc., Cincinnati, Ohio. February 1975.